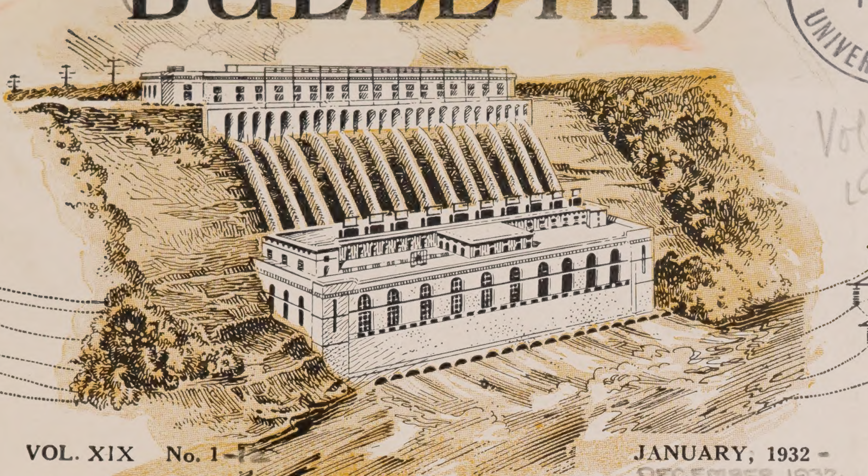
THE BULLETIN



VOL. XIX No. 1-12 JANUARY, 1932 - DECEMBER 1932

Hydro-Electric Power Commission of Ontario

Street Scene in Simcoe, Ont., Jan. 3, 1932

HYDRO MUNICIPALITIES

(Populations shown are from the last government report excepting where more recent figures have been furnished by the municipalities.)

EASTERN SYSTEM

Alexandria	2,300
Apple Hill	350
Arnprior	4,119
Athens	602
Belleville	13,914
Bloomfield	540
Bowmanville	3,662
Braeside	550
Brighton	1,311
Brockville	9,191
Cardinal	1,284
Carleton Place	4,293
Chesterville	965
Cobourg	5,619
Colborne	923
Deseronto	1,351
Finch	377
Havelock	1,421
Kemptville	1,298
Kingston	22,368
Lakefield	1,423
Lanark	581
Lancaster	560
Lindsay	7,056
Madoc	1,067
Marmora	1,023
Martintown	357
Maxville	746
Millbrook	703
Napanee	2,990
Newcastle	590
Newburgh	414
Norwood	764
Omemee	481
Orono	700
Oshawa	24,194
Ottawa	130,617
Perth	3,698
Peterboro	22,798
Picton	3,315
Port Hope	4,600
Portsmouth	620
Prescott	3,078
Richmond	362
Russell	500
Smith's Falls	7,178
Stirling	879
Trenton	5,777
Tweed	1,236
Warkworth	500
Wellington	912
Whitby	5,307
Williamsburg	200
Winchester	1,004
Total	312,668

GEORGIAN BAY SYSTEM

Alliston	1,342
Arthur	952
Bala	332
Barrie	7,311
Beaverton	970
Beeton	560
Bradford	884
Brechin	255
Cannington	878
Chatsworth	257
Chesley	1,772
Coldwater	615
Collingwood	6,126
Cookstown	635
Creemore	610
Dundalk	594
Durham	1,722
Elmvale	600
Elmwood	350
Flesherton	454
Grand Valley	583
Gravenhurst	1,776
Hanover	3,102
Holstein	285
Horning's Mills	350
Huntsville	2,608
Kincardine	2,352
Kirkfield	138
Lucknow	1,147
Markdale	798
Mc Tier	450
Meaford	2,729
Midland	7,826
Mount Forest	1,823
Neustadt	431
Orangeville	2,721
Owen Sound	12,368
Paisley	700
Penetanguishene	3,615
Port Carling	406
Port Elgin	1,261
Port McNicholl	831
Port Perry	1,185
Priceville	
Ripley	423
Shelburne	1,135
Southampton	1,718
Stayner	968
Sunderland	570
Tara	441
Teeswater	817
Thornton	200
Tottenham	545
Uxbridge	1,425
Victoria Harbor	1,104
Walkerton	2,134
Waubaushene	600
Wiarton	1,831
Windermere	123
Wingham	2,362
Woodville	405
Total	93,505

NIAGARA SYSTEM

Acton	1,903
Agincourt	612
Ailsa Craig	500
Alvinston	635
Amherstburg	2,987
Ancaster Twp.	4,124
Arkona	371
Aurora	2,596
Aylmer	1,992
Ayr	781
Baden	710
Barton Twp.	1,597
Beachville	503
Beamsville	1,175
Belle River	768
Blenheim	1,631
Blyth	618
Bolton	600
Bothwell	603
Brampton	4,993
Brantford	32,786
Brantford Twp.	7,301
Brigden	400
Bridgeport	500
Bronte	400
Brussels	706
Burford	700
Burgessville	300
Burlington	3,198
Caledonia	1,475
Campbellville	200
Cayuga	671
Chatham	16,104
Chippawa	1,450
Clifford	461
Clinton	1,936
Comber	800
Cottam	333
Courtright	394

THE
BULLETIN

Published by
HYDRO-ELECTRIC POWER COMMISSION
of Ontario

190 University Avenue
Toronto

Subscription Price $2.00
Per Year

Chats Falls Development

By F. A. Gaby, D.Sc., Chief Engineer, H.E.P.C. of Ont., Chairman Chats Falls Executive Board

CHATS FALLS hydro-electric power development, situated on the Ottawa River, thirty-six miles upstream from the City of Ottawa, is a joint undertaking of the Hydro-Electric Power Commission of Ontario and the Ottawa Valley Power Company. When completed, the project will comprise ten units of 28,000 horsepower capacity each. At present only eight units will be installed, four of which went into operation late last year; four others are to be completed by October, 1932.

The location at Chats Falls is particularly favorable for an economical development, in spite of the great length of the dam. The river banks at the dam site are low and it was therefore necessary to extend the wings of the dam upstream for some distance on each side. The dam thus is U-shaped in plan, with a crest over three miles in length, but nowhere of great height. The average head developed is 53 feet. At high stages of river flow the head will be reduced considerably and the operating head will fluctuate between a maximum of 58 feet and a minimum of 38 feet. The structures have been designed for a regulated water level at the plant of elevation 247, Geodetic Survey datum.

The Ottawa River in this section consists of two lake expanses united by the narrower reach in which the Falls are located. The upper one is Chats Lake and the lower one Lake Deschenes. Normally, the difference in elevation between these lakes was 50 feet, made up by a gradient of 12 feet in the stretch of three miles from the outlet of Chats Lake to Chats Falls and a drop of 38 feet at the falls. The additional head will be obtained by raising Chats Lake to the normal high water level.

A section of the Canadian National Railways, two and a half miles long between the dam and Chats Lake, was diverted farther inland to escape flooding due to the raising of the water level in this locality.

CONTENTS

Vol. XIX No. 1

January, 1932

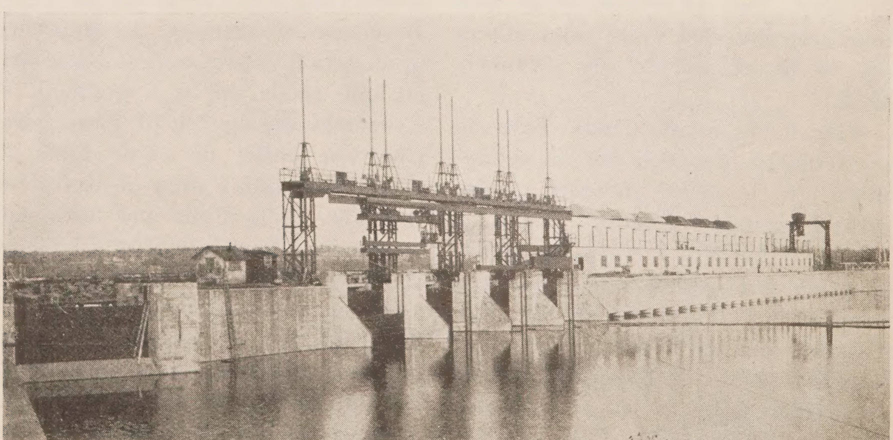
MAIN STRUCTURES

The structures, comprising the main dam, commencing on the Ontario shore, consist of an earth dyke, 4,500 feet long, followed by bulkhead and sluiceway sections reaching to the generating station at Mohr Chute. Beyond this are four sluice gates, a log slide, and again a great length of bulkhead and sluiceway sections. The total length of the bulkhead and sluiceway sections is 12,100 feet. The earth dyke was constructed of clay, well compacted by rolling and amply protected from wave action by heavy riprap. It is keyed to the concrete gravity dam by a specially designed concrete section. On the Quebec bank, which is rocky, the dam ends in a series of short, shallow concrete walls across local depressions.

Two concrete dams, one provided with two stop-log sluices, were required to close off the Mississippi Snye, a back or high water channel of the Mississippi River which joins the Ottawa River immediately above the site.

The seventy-four sluices in the main dam on the Ottawa River are 18 feet wide, with sills at elevation 225. They are divided into four sections, with forty-two sluices located on the Ontario side of the generating station, and thirty-two on the Quebec side. Timber stop-logs are used in these sluices and a travelling stop-log winch is provided at each section to handle the logs.

The sluice gate section immediately adjoining the powerhouse, on the Quebec side, contains four steel gates, 25 feet high by 40 feet wide, housed



Chats Falls Power House from forebay.

Down stream view of Power House from the north-west.

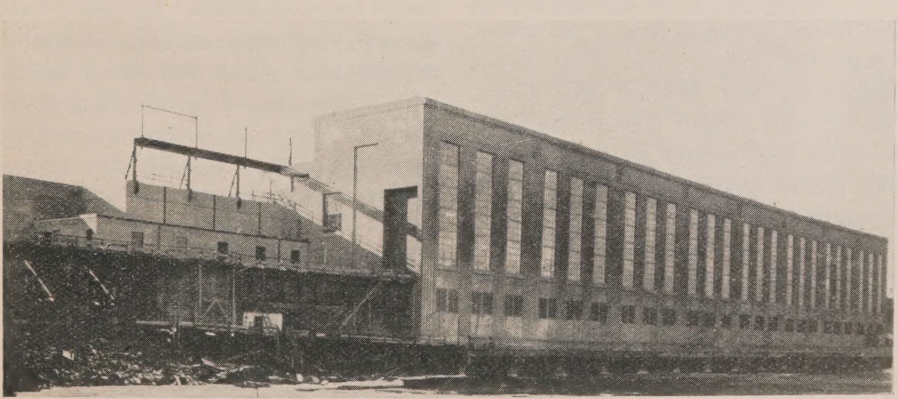
on the back with timber sheeting. These gates and also the checks they operate in are provided with heaters to assure ease in winter operation. An intake section, with a 30-foot wide opening, has been built to accommodate a log slide.

The gravity section of the dam has a top width of 5 feet at elevation 250. The upstream face is vertical, while the downstream face is vertical down to elevation 245 and slopes at a batter of 8:12 below this point. On the upstream side the dam is provided with a railing and lighting standards approximately 72 feet apart are provided from the powerhouse to the further sluices on each side.

Channel improvements are being carried out at the outlet of Chats Lake to reduce the loss between the lake and the powerhouse and, due to these improvements, the level of Chats Lake during high floods and with the dam wide open will be lower than under natural conditions.

The intake structure, or headworks, contains three water passages for each of the ten units. The main piers between units are seven feet thick and 62 feet from centre to centre, while two intermediate piers, 5 feet thick, form the water passages, which are 15 feet wide and 40 feet high at the racks, the sills being at elevation 195. At the headgates this section is reduced to 15 by 23 feet.

Steel headgates of the fixed roller



Down stream view of Power House from the north-east.

type, operated by cable hoists, are provided for cutting off the supply of water to the units and checks for emergency steel gates are located between the racks and the headgates. The housing, which encloses the hoists, forms an integral part of the powerhouse superstructure. A travelling gantry crane, operating on the deck of the headworks, is provided to handle racks, emergency gates and other equipment.

Powerhouse

The powerhouse is located with the centre line on the interprovincial boundary and, as at present constructed, extends over eight units and has a total length of 500 feet, exclusive of the two end units, for which the headworks section only has been built. The substructure encloses the concrete scroll cases and elbow type draft tubes. The floor of the scroll case is at elevation 191 and the bottom of the draft tube outlet is at elevation 156.25. The throat of the draft tube has a diameter of 16 feet 3 inches, and its section gradually changes to form two rectangular openings, 24 feet wide and 17½ feet high, separated by a central pier 6 feet thick. Piers, 8 feet in thickness, divide the units. The draft tubes project 30 feet beyond the downstream wall of the powerhouse and the piers are carried up to elevation 200, where they are spanned by a concrete deck carried on steel beams. Checks for steel gates are provided for unwatering the draft tubes.

In the upper part of the substructure, at elevation 212, two air ducts serve to convey the necessary cooling air to the generators. These ducts have six openings per unit in the downstream wall of the substructure, each opening being 5 feet by 7 feet and openings are also provided in the generator floor, with louvres to regulate the air circulation.

The superstructure and crane loads are carried on structural steel and the walls are of reinforced concrete. The architecture is simple but distinguished in appearance, the fluted columns giving the impression of solidity and strength. The main operating floor of the power house is at elevation 221 and is 47 feet wide and 496 feet long, with the units spaced at 62-foot centres. On the upstream side of the generators, adjoining the intake structure, there are three gallery floors, 20 feet wide, and serve to accommodate all auxiliary and service equipment, low voltage switchgear, battery rooms, control room and offices.

The hydraulic equipment consists of eight vertical 125 rev. per min. turbines rated at 28,000 horsepower under 53-foot head, with propeller type runners. Each machine is supplied with a Morris-Pelton electrically controlled governor, which is set on the main floor upstream from and in between the generators. The governors are provided with individual oil pumps, accumulator tanks and sump tanks, which are located on the 223 floor and the units are interconnected in pairs with ample capacity to insure against shut-downs.

Generators

The electrical equipment consists of eight 23,500 kv-a., 13.2 kv., 25 cycle, 85 per cent. power-factor generators, with main and pilot exciters direct connected to the generator shafts. The generators

Interior of Power House looking west showing generators in Ontario portion.

are connected in pairs through 13.2 kv. metal-clad switchgear to three 15,700 kv-a., 13.2/220 kv. transformers. These transformers are situated just outside the powerhouse on the Ontario side and behind the dam.

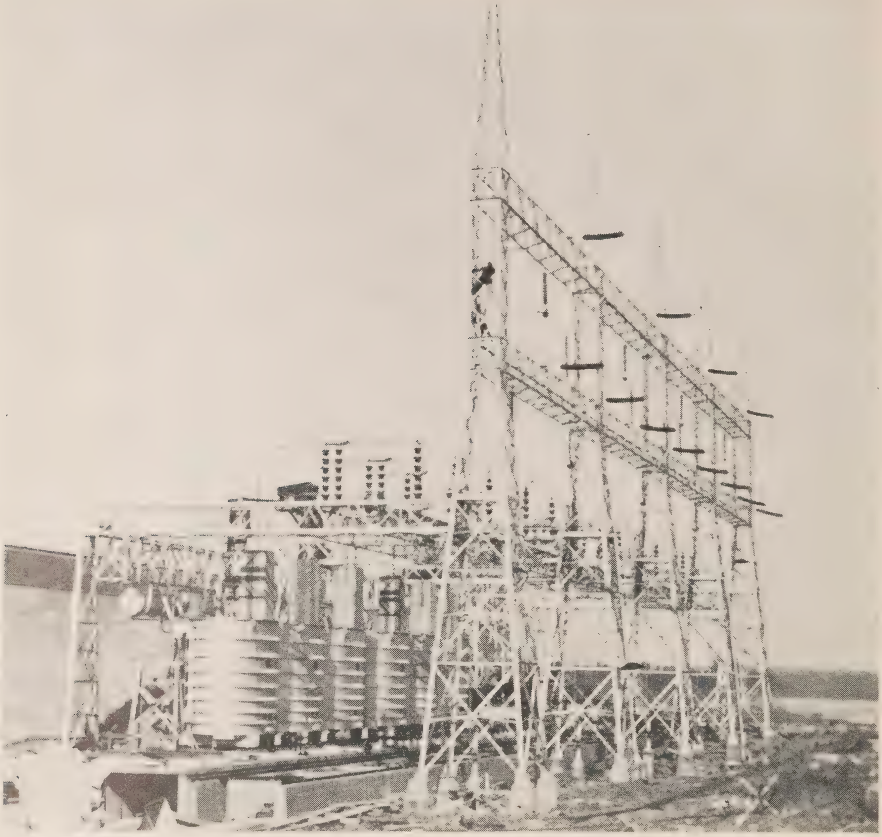
The control room is situated in the centre of the powerhouse on the gallery floor at elevation 252. Both the generating station and the transformer station are controlled from here through a 45 volt system which in turn operates the main 250 volt control system localized adjacent to the generators, oil switches and transformers. On the same floor as the control room are the battery rooms, offices and a fan room for treating the air in this section of the plant.

Switching Yards

The high voltage switching yard, which is approximately 300 feet by 360 feet, includes nine oil circuit-breakers, ring bus and disconnecting switches, with two 220 kv. outgoing lines and space for a third line and connections for four transformer leads, with space for a fifth. The oil breakers are of Deion grid type.

Construction Problems

In the construction of the project, two features peculiar to the site were



Step-up Transformer installation.

the diversion of large volumes of water during construction, necessitating numerous and long cofferdams, and the construction of a concrete dam of great length. The diversion of the water was simplified by the large number of islands and rock ridges scattered in the river channel and the comparatively shallow depth of water and also because in most cases, no pumping was required as the natural drainage behind the cofferdams provided disposal for the leakage. In the case of the tailrace cofferdam, where depths up to 25 feet were encountered, it was necessary to use steel sheet piling to secure tightness in the deep section.

The concrete mixing plant, operating two 2-yard mixers, was centrally located on Mohr Island close to the powerhouse site. The sand for aggregate was brought from a pit located about 40 miles away and stored in bins. The stone for aggregate was crushed from the rock obtained in the excavation for the powerhouse, and stored in a rock pile. The mixers delivered the concrete to heavy or light trains, made up of dump cars on standard and narrow gauge track drawn by steam and gasoline engines,

respectively. The distributing tracks were laid as a light timber trestle which ran the full length of the dam and powerhouse on the upstream side, and the concrete was placed from the cars by means of chutes.

The general construction work was carried out by Morrow and Beatty Limited, of Peterborough, Ont., work being commenced by them in October, 1929. The winter months were utilized in preliminary operations, such as building camps, erecting plant and building a railway spur, 1½ miles long, from the Canadian National Railway near Fitzroy, with the several bridges that were necessary to take the line to the powerhouse site. Active work commenced in the spring of 1930, when excavation at the powerhouse site and along the line of the dam was commenced. The number of men employed reached a maximum of 1,800. By November, 1930, the excavation at the powerhouse site was practically completed and ready for concreting operations. The following is a list of some of the major quantities involved in the construction of the project:

MAJOR QUANTITIES OF MATERIAL

Cofferdams	93,000 cubic yards
Concrete	250,000 cubic yards
Rock excavation	280,000 cubic yards
Earth dyke	190,000 cubic yards
Reinforcing steel	3,100 tons
Structural steel	1,500 tons

MANUFACTURERS

The turbines and governors were supplied by the Dominion Engineering Works and the headgates and sluicegates by the Dominion Bridge Company. The generators were manufactured and installed by the Canadian Westinghouse Company and the transformers were supplied by the Canadian General Electric Company. The high and low voltage oil switches and service electrical equipment were supplied by the Canadian Westinghouse Company. The two powerhouse cranes were manufactured and installed by the Whiting Corporation of Canada and the headworks gantry crane was supplied by John T. Hepburn, Limited, which latter company also

High voltage switch yard.

supplied the powerhouse superstructure steel.

The design was carried out by the engineering staff of the Hydro-Electric Power Commission, working under the Chats Falls Engineering Board, consisting of Dr. T. H. Hogg, chairman, and Messrs. J. S. H. Wurtele, D. Stairs and E. T. J. Brandon. This Engineering Board, in turn, was responsible to the Chats Falls Executive Board, consisting of Dr. F. A. Gaby, chairman, Col. C. W. Allen, and Messrs. H. E. Guilfoyle and J. B. Woodyatt. The Engineering Board was represented in the field by Col. H. L. Trotter as resident engineer, and O. Holden acted as co-ordinating engineer, Fred A. Robertson acting as Secretary for both Boards.

Electric Clocks

Writing in *Nature* of October 17, Prof. C. V. Boys, F.R.S., says:

"An electric clock, which vies in accuracy with the most perfect clock known, is the quartz crystal clock perfected by Mr. W. A. Marrison, of the Bell Telephone Company's research laboratory."

The "most perfect clock known," according to Prof. Boys, is that built by Shortt. Three are installed in the private laboratory of Mr. A. L. Loomis at Tuxedo Park; "Their degree of perfection could never have been ascertained without the ceaseless record of each clock every half minute by the Loomis spark chronograph. Even so, the perfection of going could not be known without the use of the quartz clock in New York connected by private wire with Tuxedo, forty miles away. The quartz clock 'ticks' 100,000 times a second and 1,000 time signals a second are sent by it along the line. These are made to actuate the spark arm and the motor which feeds the paper.

"Now the degree of perfection to which I have been leading up is no less than the certain observation of a six-hourly fluctuation of rate of the pendulum clocks under the influence of the moon's gravity. It needed the unvarying rate of the quartz clock and the thousandth of a second accuracy of each record of each clock every half minute to bring this out. At the latitude of Tuxedo the calculated accumulated error of a pendulum clock at lunar six o'clock is—0.000153 sec. as compared with lunar noon and midnight, and this is certainly shown by the clocks.

"This is such a triumph that the four who have made it possible—Hope-Jones, Shortt, Loomis, and Marrison—might well believe that the limit has been reached, and rest; but it is certain that none of them will."

—*Bell Laboratory Record.*

The New Year's Sleet Storm

By N. E. Macpherson, Assistant Engineer, Municipal Engineering Dept., H.E.P.C. of Ont.

DURING the evening of December 31 and New Year's Day, a sleet storm was experienced in a large area of southern Ontario, being particularly severe in the counties of Wentworth, Brant, Wellington, Waterloo, Oxford, Peel and York and the northern part of Haldimand and Norfolk counties. The sleet was accompanied by a high east wind which assumed the proportions of a gale during the early morning of January 1 and caused extensive damage to telephone and Hydro lines beside serious inconvenience to residents both rural and urban.

Immediately following the storm, it was realized that the area affected and the extensive nature of the damage was such that the local Hydro organizations would require assistance to meet the situation. Men and equipment were, therefore, transferred from areas least affected by the storm to districts where they were needed, and assistance given to municipalities in the restoration of service.

Relatively few Hydro poles were broken and the majority of these occured in the older lines. The damage to Hydro lines, both rural and urban, consisted mostly of broken conductors caused by tree limbs falling through the lines. This condition continued for two days, making it difficult to maintain service on lines that had been repaired and greatly impaired the progress of the work. Limbs weighed with sleet which sagged into contact with primary conductors, that under normal conditions had ample clearance, caused the greatest delay in the restoration of service. The trees were not relieved of the ice load until January 4 and this necessitated extensive tree

Typical scene along a highway showing ice loading on trees and wires.

Ice formation on a 26 kv. air-break switch.

trimming before the lines could be placed in service.

An interesting feature of the storm, particularly in the rural districts, was the unusual amount of dancing conductors, resulting in extensive damage particularly to No. 6 hard-drawn bare copper conductors on roads running in a north and southerly direction. Numerous cases were reported where the conductor had broken on both sides of the insulator at the end of the tie, leaving approximately ten inches of the conductor and tie intact on the insulator. In several districts some fifty cases were reported of 5/8-inch through-bolts used to fasten the crossarm to the pole, being broken on single-phase lines. The break occurred in the threaded portion of the bolt at a point flush with the face of the pole gain. This was attributed to conductors whipping in a manner to cause the strain to be applied first to one end of the crossarm and then to the other, producing an alternating bending action on the through bolt which finally resulted in the bolt failing.

One of the accompanying photographs gives some idea of the nature

Ice formation on No. 6 bare copper rural primary wire.

of the ice loading on rural conductors. Several samples were measured and the ice was found to be 1.5 inches in diameter around the conductor with icicles from 4 to 5.5 inches long.

The quick restoration of service, considering the amount of damage done and the conditions under which the men worked, was largely due to the loyal support shown by the men, and credit is due to all who were engaged in the work. The experience was such that it inspired R. A. Crawford, a Hydro linesman, to write the following poem.

(*With humble apology to Joyce Kilmer*)

Oh, shall I ever live to see
A line to build without a tree?

A tree whose owner will not say
You shall not carve my tree away;

A tree that looks as if 'twould say
I'll be to trim again some day;

A tree that may in winter wear
A coat of sleet, to make us swear;

Whose branches never, never grow
The way the standard blueprints show.

Lord! Let me live until I see
A line to build without a tree.

Modern Street Lighting in Windsor

By W. A. Shaw, Assistant Engineer, Windsor Hydro-Electric System.

ADEQUATE street lighting has become a decisive factor and an absolute necessity in all modern cities, due mainly to the present advance in traffic conditions. These traffic conditions have encouraged advances in street lighting, which are fully covered by the latest recommendations of the Illuminating Engineering Society. In Windsor this year, lighting has been installed on a few streets, and these installations follow very closely the code of the Illuminating Engineering Society. One of these installations, that of Tecumseh Road, which has just been completed, is here described in detail.

Tecumseh Road can be classified as a main thoroughfare. Between curbs there is a width of 54 feet. In the centre of the roadway, islands 18 feet wide have been left, which make a driveway of 18 feet on each side. These centre islands can be used for laying future street railway tracks, but as this does not appear likely now, they will probably be planted with shrubs and flowers.

Before the new lighting was installed, there was a wooden pole line along the south side of the street, with ordinary bracket lighting. Along one-half of this south side, there were 45-foot wooden poles carrying a 26 kv. line, two 4 kv. lines, several series wires, and a Hydro telephone line. All these wooden poles and series wires have been eliminated from the street.

On both sides of the street, Union Metal heavy duty fluted steel poles varying in height from 26 to 50 feet, and with bottom shaft diameters from 9 to 12 inches are now used. These poles have a 17-inch square cast steel base

Tecumseh Rd., Windsor, looking west from McDougall St. at Jackson Park with 45 ft. and 40 ft. poles on the left and 26 ft. poles on the right.

which is mounted on a concrete foundation, by means of four anchor rods. The bolt circle is 16 inches. This has been made standard for all sizes of poles, and styles of bases. With this standard bolt circle, it will be possible to change to different poles if necessary, without changing any foundations. All steel poles from 26 feet up to 40 feet, are in one section, and are made of No. 7 gauge steel. The 45 foot and 50 foot poles are in two sections, with the bottom section of No. 3 gauge and the top section of No. 7 gauge. Where street lighting alone is provided for, 26 to 28 foot poles are used, but where the 26 kv. and 4 kv. lines are provided for, 40, 45 and 50 foot poles are used. The spacing of all poles is approximately 120 feet, and the arrangement is opposite. This spacing, if street lighting alone was considered, could have been increased to about 150 feet.

Street lighting units are installed, one on every pole, at a mounting height of 21 feet. Each lighting unit consists of a Form 32 Novalux pen-

dent luminaire, mounted on an ornamental cast iron bracket overhanging the curb. The lamps used are 20 ampere, 6,000 lumens, with a light centre of 7 inches, and burning base up, in a No. 146 light alabaster rippled C.G.E. globe. The lumens per linear foot of street are 100 to 120. Higher intensities can be obtained merely by changing the lamps to a higher rating. Provision has been made on each pole for the addition of a second bracket to give future twin lighting.

Current is supplied from 2—20 kw., 20 ampere constant current outdoor regulators, one for each side of the street, but mounted off the street. An overhead series wire is used, and is carried on an ornamental steel arm, where it is broken on a double groove insulator. From here, duplex cable is taken on the inside of the pole and bracket to the lamp socket. These 20 ampere circuits have a maximum of a 1,000 volts, approximately one-third of the voltage of a 6.6 ampere circuit. This system is found to be economical, and very satisfactory. The initial cost of underground cable and individual transformers is saved. The losses from these transformers are also eliminated.

This completed installation has been quite a departure for the City of Windsor, and many favorable comments have been received.

Tecumseh Rd., Windsor, looking west from Marentette Ave. with 26 ft. poles on both sides.

Application of Hydro-Electric Power to Farm Work

Article No. 23

INTERESTING events in the history of farms in Ontario occasionally come to the attention of the Commission's engineers in the course of their duties. This article deals with a few on the farm owned by Mr. Moses Honsberger at Bridgeport, near Kitchener.

About 1820 in settling on this farm, a relative of Mrs. Honsberger located his buildings in the valley near the mill, at one end of the farm which is about a mile long. After operating the farm with this set-up and when extensive repairs became necessary to the buildings, the present owner decided in 1927 to build a complete new set of buildings near the centre of the farm on the higher land. In making plans for the new buildings, Mr. Honsberger decided they must be as complete as possible in every detail, and Hydro-electric service was given close attention a to applications to the needs in the house and barn for light, power, cooking, etc. Installation in the owner's and man's houses:

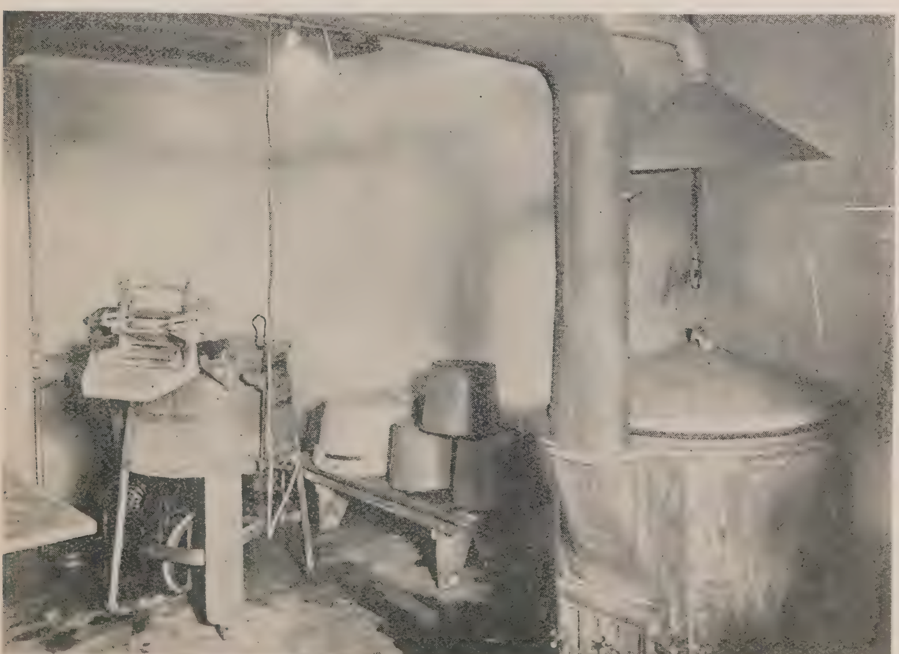
Lighting, about......	1,500 watts
Range with coal annex	7,000 "
Washing machine....	350 "
Automatic soft water pumping system...	250 "
Blower for booster heat delivery..........	50 "
Electric irons (2).....	1,200 "
Vacuum cleaner......	50 "

Installation in barn and other buildings:

Lighting...........	750 watts
10-h.p. motor for threshing, chopping and silo filling.....	9,500 "

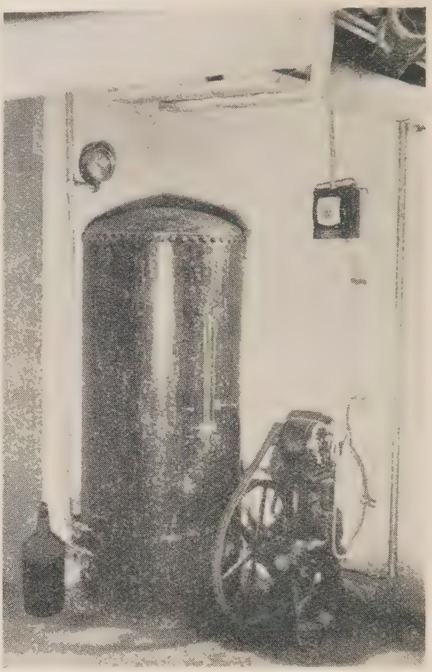
Owner's house, barn and garage. The hired man's house and the implement shed do not show in this cut.

The electric range with coal annex is now found on many farms. The iron and vacuum cleaner are as much appreciated by the farmer's wife as her sister in town.



The laundry with its dowel-type washing machine, tubs and water heater. The latter is used for supplying hot water at pig killing time and for other purposes.

Bathroom on another farm in the same district, showing electric water heater. It was not possible to secure a picture of the bathroom at the Honsberger farm.



The automatic soft water pumping system. The heat booster motor is between the furnace pipes above the water tank.

¾-h.p. motor on deep-well, hard water pump serving house and barn..........	750 "
	21,400 watts

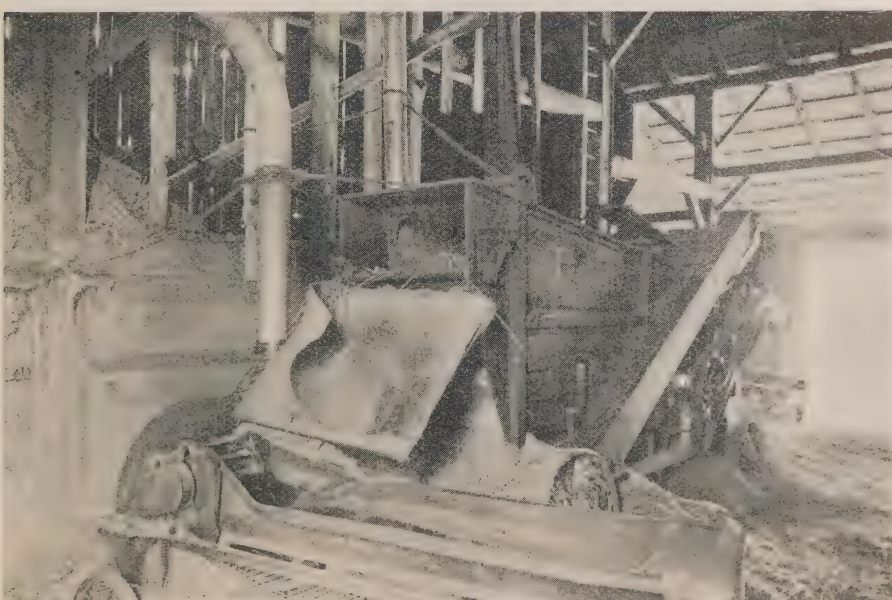
There are many individual threshing and silo filling outfits in the county.

Man and team ready to go to the field for another load of grain. Beside the racks at the front and back, a wire gate serves as rack enclosure at one side. The driver pitches on his load and on arrival at the barn feeds it into the thresher.

A 20-inch cylinder thresher operated at a cylinder speed of less than 1,000 rev. per min. Note the cutting box at the back.

These two pieces of farm machinery on this farm control the size of the barn motor. The chopping and other work could be done with a much smaller motor as 1.5-h.p. motors are doing this work on many other farms, but Mr. Honsberger believes the saving in labor and trouble justifies the larger motor.

The farm is 200 acres with 138



The cutting box at the back handles the straw, cutting and blowing it to the mow. The curled metal on the delivery board lays the straw lengthwise on the feed table, which carries it to the rollers that feed the cutter.

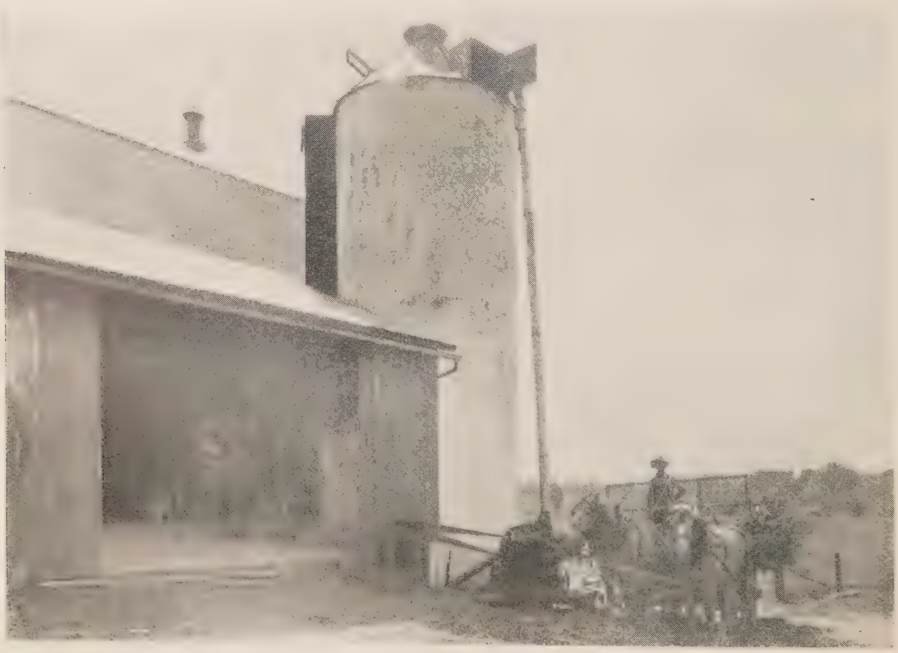
acres in crop. All grain is threshed and straw cut as the crop is hauled in. The cut straw, grain and chaff are delivered automatically to granary and mows by elevators and blowers. The silo filling box is used at the back end of the thresher for cutting and blowing the straw, thus using this piece of equipment for more than silo filling. Each man, when hauling in grain, loads his own load in a specially arranged rack wagon and throws it into the threshing machine on arrival at the barn.

There seemed to be no rush in doing the work and the harvesting on this farm seemed to be much ahead of neighboring farms at the time of the visit of the Commission's engineer during the harvesting.

Silo filling, like the threshing, is done by the help of the farm, only two hired men and the owner, using the same cutting box as for cutting the straw when threshing.

The successful operation of the thresher and silo filling box depends on driving them at the proper speed for the power available. There is a tendency to try to drive at too high speed and in many cases the object is defeated as the power available will not maintain the objective speed when doing work.

Another interesting use on this farm is a booster blower to deliver



The silo is 12 feet by 40 feet and has a capacity of about 120 tons of cured silage. The box is operated at a speed of 800 rev. per min., which is probably correct as the cutter wheel is relatively small in diameter. The rate of putting corn in this silo with this box and the 10-h.p. motor, should be 12 tons per hour or more. As the work on this place is done without extra help, it is probably done at a lower rate.

hot air from the furnace to the living room, washroom and kitchen when winds from that direction affect the natural circulation.

The service to this farm is class 6A. The rates are:
Service charge — $5.16 per month.
Consumption charge — 3 cents per kilowatt-hour for the first 126 kilowatt-hours used each month.
1.25 cents per kilowatt-hour for the balance of the current used in each month.

The total consumption and cost of service for the year ending June 30, 1931, was:

Period	Consumption in Kilowatt-hours Total	Consumption in Kilowatt-hours — 2nd Rate	Total Net Bill
3 months ending April 30, 1930.....	1,360	982	$ 35.21
3 " " December 31, 1930.	830	452	29.25
3 " " March, 31, 1931 ...	880	502	29.81
3 " " June 20, 1931......	650	272	27.23
	3,720	2,208	$121.50

Hydro-Electric Progress in Canada in 1931

(From a report by Dominion Water Power and Hydrometric Bureau, Department of Interior, Ottawa.)

A YEAR of widespread activity in the development of Canada's water power resources is disclosed in the annual review of hydro-electric progress issued by the Dominion Water Power and Hydrometric Bureau of the Department of the Interior. This review shows that during 1931 water wheels or turbines actually installed and brought into operation totalled 546,650 h.p. Taking into account a number of replacements of old by new installations, the net increase for the year brought the total water power installation in the Dominion to a figure of 6,666,000 h.p.

In addition to this substantial total of completed installations, construction was advanced upon a number of undertakings some of which are of great magnitude. It is expected that these will be brought into operation within the next two or three years and will add more than 1,400,000 h.p. to the Dominion's water power development.

It is estimated that capital to the extent of at least $110,000,000 has been expended in providing for the development, transmission and distribution of the new power developed in 1931, while more than $280,000,000 will be required to bring to completion the projects at present actively under construction. These large expenditures in the development of one of Canada's most important natural resources are most timely in providing employment to thousands

of citizens in a great many lines of endeavour. It may be contended that with the present lessened demand for power, due to depressed business conditions, the programme of water power development is too far in advance of existing needs, but it is confidently expected that with improved conditions, of which there are already signs, the power demand throughout the Dominion will quickly absorb the available supply.

During the year Quebec took the lead with new installations totalling 382,200 h.p., while in the other provinces the figures were, British Columbia, 25,200 h.p., Manitoba, 79,000 h.p., Ontario 58,200 h.p., and Nova Scotia 1,650 h.p. Large undertakings are at present under construction in Quebec, Ontario and British Columbia. The installations completed in each of the provinces are briefly described in the following paragraphs.

British Columbia

Active progress was made in 1931 upon the construction of a number of hydro-electric undertakings in British Columbia which resulted in new installations to the extent of 25,200 h.p., being completed and placed in operation while work on other projects was well advanced.

The Powell River Company, Limited, brought its new Lois River plant into operation in the month of March with the first unit designed to deliver 24,800 h.p., under a net effective head of 375 feet, provision being made in the power station for the addition at a later date of a second unit of the same capacity. The electrical energy from this development is transmitted about thirteen miles over a 66,000 volt line to the Company's pulp and paper mills at Powell River.

On the Bonaparte River about three miles above Ashcroft, the Ashcroft Water, Electric and Improvement Company, Limited, completed the installation of a 400 horsepower hydro-electric plant. Power from this plant serves the town of Ashcroft and vicinity and it is also proposed to use part of the output for irrigation purposes in the district.

Manitoba

In Manitoba two large hydro-electric undertakings on the Winnipeg River were brought into commercial operation with initial installations.

At Seven Sisters the Northwestern Power Company, Limited, a subsidiary of the Winnipeg Electric Company, formally opened its new plant on July 15th. The power station has been completed to house three main units each of 37,500 horsepower, or a total installed capacity of 112,500 horsepower. Eventually three more units will be added bringing the total designed capacity to 225,000 horsepower. The plant is at present operating under a partial head of about 41 feet which permits the three installed units to produce about 55,000 horsepower. A steel tower transmission line of 110,000 volts, sixty-three miles in length has been constructed to carry the power to Winnipeg.

At Slave Falls the City of Winnipeg completed the initial stage of its new development and the plant was formally opened on September 1st. The power station has been completed to house four units or half of

the final development, the initial installation consists of two 12,000 horsepower units and the ultimate capacity is 96,000 horsepower in eight units of 12,000 horsepower each. A 91-mile 132,000 volt steel tower transmission line has been built to carry the power to Winnipeg. At present this is being operated at 66,000 volts.

ONTARIO

In Ontario activities during the year were practically confined to two large undertakings, one at Chats Falls on the Ottawa River and the other at the Canyon on the Abitibi River.

At Chats Falls the Ottawa River forms the boundary between the Provinces of Ontario and Quebec and the power development has been carried out as a joint undertaking by the Hydro-Electric Power Commission of Ontario, controlling the Ontario rights and the Ottawa Valley Power Company, Limited, those on the Quebec side. The joint power station is located astride the interprovincial boundary and is designed for an initial installation of 224,000 horsepower in eight units under a head of about 53 feet. Provision is being made to increase this to 280,000 horsepower, when flow conditions warrant. Construction work on the dam and power station was virtually completed during the year and four 28,000 horsepower units have been installed, and are now in operation. Work on the remaining units is underway. A 220,000 volt steel tower transmission line from Chats Falls to Toronto was completed and placed in operation.

At the Canyon on the lower Abitibi River in Northern Ontario, the Ontario Power Service Corporation, Limited, a subsidiary of the Abitibi Power and Paper Company, Limited, has a large development under construction. A high dam is being built in the rocky gorge which will provide a head of about 237 feet. The plant has been designed to include five units of 66,000 horsepower each or a total of 330,000 horsepower. The Hydro-Electric Power Commission of Ontario has contracted with this Company for 100,000 horsepower which will be delivered to the Sudbury mining district over a 132,000 volt transmission line, 250 miles in length. Good progress was made in construction operations during the year, work at the dam being well advanced and the transmission line completed from Hunta to Sudbury. It is expected that power will be ready for delivery in the autumn of 1932.

At Sault Ste. Marie, the Great Lakes Power Company, Limited, installed a new unit of 2,200 horsepower in its hydro-electric station replacing three smaller units of 350 horsepower each.

QUEBEC

In Quebec new water power installations during 1931 reached the substantial total of 382,400 horsepower. There are as well a number of large projects under active construction which will be ready for operation within the next two years.

As has already been described in the Ontario section, the joint development at Chats Falls on the Ottawa River of the Ottawa Valley Power Company, Limited, and the Hydro-Electric Power Commission of Ontario, has been brought into operation with four units of 28,000 horsepower each.

The Alcoa Power Company, Limited, completed the Chute-a-Caron plant on the Saguenay River from which power is to be used for the reduction of aluminium ores. The installation has a total capacity of 260,000 horsepower, in four 65,000 horsepower units. This plant is the initial step in the Shipshaw development which is to have an installation of 800,000 horsepower under a head of 210 feet.

Gatineau Power Company completed the installation of the seventh 34,000 horsepower unit in its Paugan plant on the Gatineau River raising the installation in this plant to a total of 238,000 horsepower.

The municipality of Ste. Agathe des Monts replaced two units of 200 horsepower each in its plant on the North River by two new units of 300 horsepower capacity.

A La Gabelle, on the lower St. Maurice, the Shawinigan Water & Power Company placed in operation the fifth unit, completing the intended installation at this plant. The new unit of 32,000 horsepower has a higher rating than the other four bringing the total installation to 152,000 horsepower.

NOVA SCOTIA

Hydro-electric construction in Nova Scotia was not as active in 1931 as in recent years but certain works were carried out chiefly in connection with existing systems.

The Nova Scotia Power Commission constructed a new plant of 1,350 horsepower capacity at Rapid Falls on the Mersey River. This plant was constructed to increase the power available for the Mersey Paper Company and to supply the Markland and Mushamush systems of the Commission.

The town of Annapolis Royal completed the replacement of 245 horsepower unit in its hydro-electric plant on the Lequille River by a new one of 300 horsepower capacity.

Re: Aluminum Paint on Poles

On page 379 of the October issue of THE BULLETIN, there appeared an article referring to "Precautions in Setting Poles", which had been printed in the September issue and which referred to the painting of creosote poles with aluminum paint. This practice was questioned and a request was made that work of this nature would be deferred until this matter could be further investigated.

This investigation has now been made. One of the conclusions drawn from these Laboratory tests is—

"The electrical characteristics of two coatings of aluminum paint appears to be almost exactly equivalent to the surface film of moisture standing on a wooden pole after fifteen minutes or so of rain. It is not an insulator and while the resistance is high, it might readily carry sufficient current to be hazardous to anyone coming in contact therewith. Passage of heavy current seems to increase the resistance permanently but with our tests up to the present, we cannot comment on the effect on the life of the paint film."

We would therefore recommend that aluminum paint be not used on poles or crossarms in order that the insulating value of the wood may be retained.

The Truth About Trees

By W. Ray Hunter, in charge of Forestry Section, Operating Department, Hydro-Electric Power Commission of Ontario.

(*Read before Association of Municipal Electrical Utilities at Toronto, January 28, 1932.*)

IT is only in recent years that people generally have been awakened to the real value and importance of trees. Naturally, with the growth of appreciation and love for these monarchs of the plant kingdom, there has been greater opposition to improper methods of pruning.

The Public Utilities are not alone responsible for all the atrocities found in our travels throughout the North American Continent; in every community we find individual property-owners, private clubs, and municipal authorities have permitted the destruction of trees by employing workmen without a knowledge of, and practical training in, the proper method of pruning.

During the winter of 1930-31 one municipality, desiring to extend a helping hand to the unemployed, put all of the idle men in their community to work pruning the village trees. No one could criticize the motive—it was a commendable cause—but the evidence bears everlasting testimony to lack of judgment. One citizen realized what was taking place and notified the authorities that he would resort to whatever means necessary to prohibit the men from pruning the trees in front of his property. What was at one time a village with beautiful tree-lined streets is now devoid of their grace and splendor.

Elbert Hubbard, the American author and founder of The Roycrofters at East Aurora, N.Y., has written: "For two hundred years the destruction of trees was the chief intent of man in America. And so recklessly and completely did ax and torch do their work that, in certain sections, millions of acres have been rendered practically uninhabitable. These waste places are called with fitting phrase 'slashings'. The entire racial instinct has been one of enmity, or at least indifference, toward the tree. When we thought that trees should be trimmed we chose the local village 'setter'—the doer of odd jobs—the most ignorant, dissipated, depraved, unlovely and unlovable man in the place. I suppose the idea was that if he fell out of a tree and broke his neck it would be small loss to the community.

"And that he trimmed the trees, the aspect of most village streets can testify. He certainly fulfilled the Bible injunction, and did those things which he ought not, and left undone the things he should have done."

We are indebted to the founder of this great public institution, in which we have the privilege to serve. Sir Adam Beck, in his profound wisdom and understanding, saw clearly the situation facing the Utilities as early as June, 1915, ten years before the idea had been given serious, if any, consideration by anyone else in the

Mutilation by the village "setter".

industry. A man of some practical experience in the proper method of pruning trees was employed to organize a squad of men for this purpose. He was assigned to the construction department and functioned under their direction for a period of six months or more. Another attempt was made to improve the standard of work along this line, when in November, 1921, an expert was employed to organize a squad and carry on the same work; this also was abandoned a few months later to permit him to give personal instructions to regular employees of the Commission. This method likewise was not found practical, so that it too was given up in April, 1922.

It was not until two years later, sometime in 1924, that one of the large American Utilities employed a nationally known tree expert company to carry on experiments in scientific tree pruning for line clearance. The undertaking was, without a doubt, successful. The costs were not excessive, furthermore the tree expert company experienced no difficulty in securing permission from the property-owners to prune their trees. On the contrary, many wrote the Power Corporation expressing gratitude for the progressive step they had taken and commenting upon the improvement that had been made in the condition of their trees.

Is it any wonder that this Utility has expressed itself in the following words: "We realize, of course, that outside of the desire for uninterrupted economical service to the customer, there is probably nothing closer to us than the desire for good public relations; and that except for the actual serving of our customers with energy,

A side slashed pine tree.

there is no greater contact with the public, no greater opportunity to build up or tear down friendship and good feelings for a utility than exists in the necessary maintenance of the trees along the conductors. The experiment proved a success from operating, public relations, safety and economic standpoints; and to-day the 'tree experts' are responsible for all but one hundred miles of our overhead distribution system."

No man had a greater sense of compassion and consideration for his fellowman than Sir Adam Beck; it is, therefore, only natural that with his love for trees and the beauties of nature, he would not be discouraged in his desire to inspire the organization he created with higher ideals for greater public service, so that again in April, 1925, he assembled a group of employees in the Commission's

Crown pruned and symetrically shaped maple tree.

Elm trees under pruned to clear line.

construction department and personally gave them instructions in the proper method of pruning trees and waterproofing the wounds.

Everyone has had an earnest desire to perfect the mechanical and electrical equipment of the distribution systems, to express a higher understanding of engineering principals, and by reason of this desire much has been accomplished. The progressive and open-minded executive has been deeply concerned in the tree trimming question and eagerly sought the solution. Some have found the tree expert companies the answer, others have thought it wise to establish a separate department where men could be trained in the scientific and practical methods of performing this work. Still other companies have prepared booklets with detailed instructions and illustrations, hoping that in this manner they might improve the work that is being done by their regular staff; and occasionally we find some

Specimen of pruning and shaping for line clearance.

who are so situated that they may call upon the local Parks Department.

Nothing has been said of the economic side of the question, and to many of us it may not appear of sufficient importance to cause any great concern. It is, nevertheless, of considerable magnitude. One American power company appropriated one-quarter million dollars to cover their 1930 line clearing activities. One of the tree expert companies employed by a number of the utilities to do this work shows a 1930 volume which amounts to approximately one-half million dollars. There are numerous other tree expert companies engaged in this work—some exclusively. Can you imagine the total amount of money spent in this one activity by all the power interests? There is no doubt but that it is well into the millions of dollars. Such an outlay can no longer be treated with indifference.

The N.E.L.A. appointed a joint committee to study the subject of trimming trees as it affects the Utilities, and in January, 1931, they published a bulletin No. 110 which deals with this matter in detail. In it you will find this significant statement: "It must be borne in mind that the satisfaction or disapproval of an entire community is directly affected by a company's tree policy. The tree problem, therefore, is a responsibility shared by the utility and the public—that demands the closest co-operation between the two parties concerned for the conservation of both trees and electric lines."

Little more need be said as to the cause of public antagonism. It is, doubtless, a result of the indifference and ignorance manifested, and with this uppermost in our minds we should come to the conclusion that each one of us has a responsibility to ourselves, the organization we represent, to our fellow citizens and to our country, to gain sufficient knowledge and understanding of trees, so that we may, through corrective pruning, remove the unsightly evidences of past efforts and perform a work in the

future comparable to the advancement made in all departments of the utility field.

There are certain well-defined laws governing the life process and function of trees, just as there are for every other part of the Divine creation of Life. Trees live and breathe the same as you and I; they perform every function except that of locomotion and what we understand to be intelligence. Through study of the structure of a tree we find it to have five vital and inseparable parts:

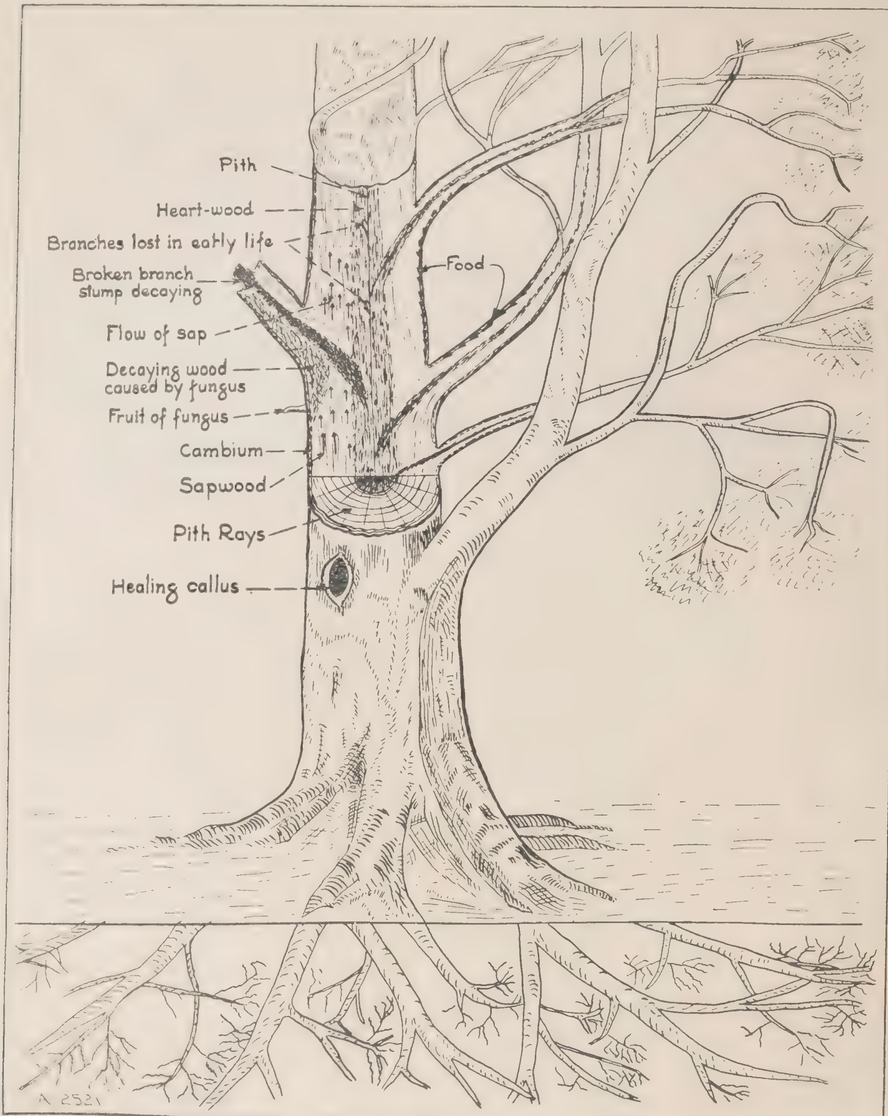
The Root System is the foundation upon which the tree must rest and be maintained in its upright position, it increases year by year in direct proportion to the growth of the branches and twigs in order to maintain an absolute balance. The root system usually extends in length and breadth similar to the super-structure. The food-gathering roots, which are not larger than a hair, are generally found at the extreme ends and are commonly known as "rootlets". They are formed especially for this purpose after the harder particles, or root caps, have been worn off, guiding and breaking the way for another year's growth.

The Trunk and Branches need not be dealt with separately since they are identical in structure, the only difference being in diameter. Looking at the cross-section of a tree we find a cylinder of wood, surrounded by rough bark, or covering, designed to protect the cell structures, consisting of four intregal parts different in composition and function, which must not be exposed to the elements, insect attacks, fungi, or mechanical injury without resulting in detrimental effects upon the life of the tree.

The Cambium Layer is a very thin cell tissue, situated between the bark and sapwood and is not distinctly separated from either. Its chief function is to complete the cycle and flow of digested available food supplied to all parts of the tree for growth. During the growing season, through the continuous process of division it forms an inner and outer layer, both of which are called the annual ring.

The Sapwood is composed of tube-like cells over-lapping each other

Maples hedge pruned for line clearance.



Tree structure Chart showing cross section.

and which are continuous from the tips of the root system to the extreme ends of the twigs. They function as channels for the flow of sap (the minerals gathered from the soil). The outer layers are most active in this process, the inner layers being used for a food storehouse.

The Heartwood is composed of inactive cells in layers and serves as a mechanical support for the tree. During the early life of the tree each layer has in turn served

as the cambium, and sapwood, but through that systematic process of life, beyond human conception, they have been transformed both in structure and function. The innermost layer surrounding the pith represents the first year's growth, the next layer is the second year's growth. With each succeeding year you will find another layer which we call annual rings. A complete history of the life of each tree is written in these rings. Drought is shown by a very thin ring. An abundance of moisture is evidenced by a heavy thick ring. Where branches have once grown and have been removed, even insect attacks and mechanical injuries, are clearly distinguished.

The Leaves are a most important part of the tree and have a triple function to perform. They are the digestive organs and through the process of purification and chemicalization the raw minerals gathered from the soil by the roots are made available food and, upon flowing through the cambium layer, the new and living cell tissues are formed.

The leaves are also the lungs, and while breathing takes place in other parts of the tree, the major portion is performed through them, extracting carbon dioxide from the air and dispelling oxygen—the reverse of what takes place in our lungs when we take oxygen from the air and give off carbon dioxide. The leaves are also required to perform the function of transpiration and an ordinary size tree gives off many gallons of water daily.

The systematic balance of every part of the circulating system of a tree is of utmost importance to the normal and orderly process of life. There is no doubt that when one or more parts have been disturbed or destroyed, a detrimental effect will naturally result, at least until such time as the balance has been re-established, or in the struggle to do so the tree has died. Either one or the other must take place—there is no half-way nor uncertainty.

The Growth of a Tree is its principal function. This is performed by two entirely different methods; the extension, or increased length of roots and branches, and the increased diameter of the whole tree. Before the leaves have fallen in autumn, and the tree has taken on that so-called dormant aspect, a pre-determined growth has been established by the formation of terminal buds on each twig. With the coming of spring, when the tree resumes its outward manifestation of full life, it grows in height and breadth by extensions from these buds, each bud serves for the growth of one year. New ones are formed for each succeeding year's growth. In the root system that same orderly process prevails, the only difference being the formation of root caps, a hard callous, instead of buds. These are worn off in breaking up the soil, making way for the tender growth to follow. The diameter growth takes place in all parts of the tree through the process of division in the cambium layer, previously explained.

The Species of trees differ in character, habit, color and form quite the same as in the human race. Within the same specie of tree we find that each one has its own individuality, no two are exactly alike. There is a marked difference in the

annual growth of the decidious trees; for example, the Manitoba Maple (otherwise known as the Box Elder), often has as much as six or eight feet of growth in a single season, whereas some of the hardwood trees may only grow a few inches. The same condition prevails in the coniferous trees except the contrast is not so great.

Pruning trees for line clearance involves three distinct methods—crown pruning, sometimes called topping—side trimming and under pruning.

Crown Pruning should be avoided wherever possible, never hedge prune—a flat topped tree is no thing of beauty. Conductors directly over the crown of a tree are in the path of natural growth and to keep the circuits clear is a costly maintenance problem.

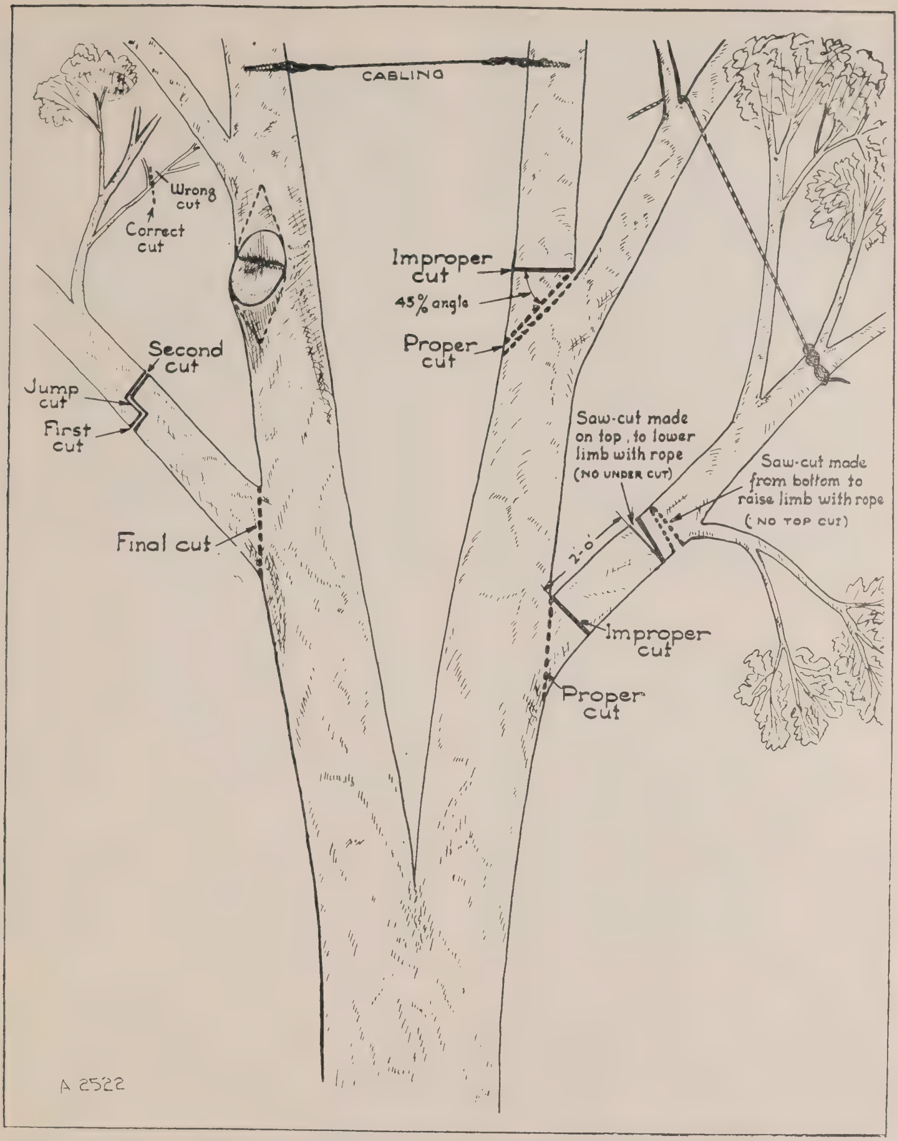
Side Trimming in the majority of cases can be done without disfiguring the tree, and by intelligent pruning on all sides they can be symmetrically shaped. Never slash the side off a tree and beware of notches.

Under Pruning is the most desirable of all as a tree can generally be pruned to overhang the wires and by removing branches on all sides to a uniform height, especially in elm trees, a perfectly shaped specimen results and maintenance pruning cost is reduced to a minimum.

The execution of these pruning methods involves obedience to certain fundamental laws. Contrary to the general belief that heavy pruning provides greater clearance, heavy pruning forces an abnormal growth. One fact should be kept constantly in mind—pruning live wood out of a tree necessitates an equal amount of growth. Tipping branches—the removal of terminal buds—will control tree growth far more effectively. All cuts must be made flush to the parent stem. It is no doubt the most difficult cut to make and whether it be a saw or pruner cut, in a large branch or a small twig, correct pruning demands a flush cut, otherwise the cambium layer cannot perform a natural healing and enclose the wound.

Guying: There is only one method of cabling and guying which will not cause serious or permanent injury. Guying or anchoring a pole line to a tree may be done in this manner: bore a hole into, or even through, the trunk; cut the bark around both ends of the hole, slightly larger than the size washer to be used, insert a threaded rod far enough to permit washers and nuts to be put on both ends and drawn snug, after which guy wires may be attached to the long end of the rod.

Cabling: It is often found necessary in order to protect the power line or preserve a fine old specimen, to cable a splitting crotch. This is done in a similar manner to guying except that holes are only bored deep enough to take a lag screw, or tree hook. It is not necessary to trace or cut back the bark in this case since washers and nuts are not used. Cable cut to proper length is spliced around thimbles and by the use of a block and tackle the forked stems are drawn together so that the thimbles can be placed over the hooks. When cabling a tree during the dormant period it is only necessary to have the cable snug. But when a tree is in leaf the cable must be quite tight,



Scientific pruning and cabling chart.

otherwise it will be very loose when the tree has shed its leaves.

Detecting the weak and splitting crotches in the early stages requires keen observation. While they may be found in any tree, you will find this condition in maple trees but more pronounced in the elm trees which are prone to develop the V-crotch, a structurally weak type. The broad U-type is usually healthy, strong and seldom requires attention.

Wound Dressing: It is imperative that all saw cuts be painted or waterproofed. In fact the pruner cuts should be treated in the same manner,

but they are usually difficult to reach and being small in diameter heal during the first growing season. There are many different theories as to the best materials for this purpose, but an asphalt base paint is generally accepted as the best since it is comparatively free from penetrating qualities and forms a plastic covering over the wound protecting the cell structure from the elements, bacteria, fungi and insect attacks. Wound dressing will not ordinarily last over one year and should be renewed at frequent intervals.

In conclusion it is well to summarize a few of the common practises which are detrimental to the life functions of the tree and should be prohibited:

Bark Injuries many times occur through carelessness and ignorance in handling tools, chains or raising a pole. Do not use a tree for temporary anchorage unless the trunk is wrapped with several thicknesses of burlap and not even then if it can possibly be avoided. Wherever the bark is injured the exposed wood must be protected with an asphalt base dressing.

Stubs mean any part of limb, branch or twig, that projects beyond the parent stem, whether two inches or two feet in length, correct pruning requires that they be removed by a flush cut.

Topping is extremely dangerous practice and particularly so in hard maples, beeches and oaks. At best it is unsightly and therefore should be avoided.

Stripping or peeling the bark is caused by trying to remove a large branch or limb with one saw cut, when two are necessary to do it right. The first cut should be made a foot or more from the point where the final cut is to be made, the simplest and safest method is the jump cut; first, under-cut the branch or limb six or eight inches from the point of final cut—second, cut is from the top of branch, cut six or eight inches further beyond the under-cut—third, flush cut to remove the stub.

Wounds that have not been waterproofed with a suitable preparation will inevitably decay, and once this destructive agency has begun its deadly work it is only a question of time before the tree succumbs to a premature death.

Brush must not be left lying around, it is unsightly and aggravating to the property-owners and passersby. Fires near trees oftentimes cause serious damage—excessive heat forces abnormal transpiration followed by inevitable scorching of leaves and branches, sometimes even the whole tree.

Root Damage in the majority of cases can be avoided. Oftentimes the location of a pole may be varied slightly to eliminate the necessity of destroying tree roots.

Cabling, Guying or Anchoring should never be done by placing a band or wire around the trunk or branch of a tree, nor by using blocks of wood and leaving ample room in the wire loop; the pressure of the blocks retard circulation in the sapwood and cambium layer, furthermore it prevents breathing through lenticels in the bark and will eventually girdle the tree. The proper method has been previously explained.

Spurs puncture the bark and cambium layer, consequently they are injurious to both and should never be

Maple tree before and after pruning.

included in the tool equipment for a line-clearing squad.

Permissions are essential in the successful management of a line-clearing operation. The importance of this is clearly set forth in the following quotation taken from the Municipal Institutions Act—Chapter 233, Section 499, which says in part:

> (1) In this section "tree" shall include a growing tree, or shrub planted or left growing on either side of a highway for the purpose of shade or ornament.
>
> (3) Every tree upon a highway shall be appurtenant to the land adjacent to the highway and nearest thereto.
>
> (4) The council of every municipality may pass by-laws.

There are only a few of the municipalities that have passed by-laws designating the proper authority for the care and preservation of trees. Much confusion has necessarily resulted through divided ownership. This convention can perform a real public service by appointing a committee to study the situation as it affects tree trimming for line clearance; the establishment of a constituted authority for control of all trees now standing on and overhanging the highways; regulating the species and planting of ornamental and shade trees on the highways; prohibiting the unnecessary injury and destruction of trees. Where by-laws do not exist it is expedient to secure permission from municipal, township and county officials as well as each property-owner, and where not obtained, pruning should not be done except in case of immediate necessity for protection of life or property.

No more fitting words could be found to leave with you than Charles Divine's poem entitled—

A REVERENT TOWN

I like a town that sees
The sacredness of trees
Acknowledging their right
To whisper half the night,
And all the day to talk
Above a shaded walk.

I like a reverent town
That hews no tree-trunk down,
But lets it stand to know
Sidewalks around can go,
As if: "I comprehend,
You were here first, my friend!"

Courtesy of *The Canadian Motorist*

The following notice was recently seen on a Hydro storeroom and illustrates the interest shown in this particular instance with regard to the proper care of stores.

A proper heading might be: "One way of keeping stores in order."

NOTICE

In case material is needed you can arrange getting same by calling on Store-Keeper or someone connected with this office. Anyone doing same is doing so at your own risk. We are trying to keep things in shape and are going to see that they are.

By Order.

Wide Use of Electricity

Of the 2,142,805 homes in Canada, 1,436,777 or 72 per cent. are wired for electricity, according to a recent survey by a large company manufacturing electric appliances. In these homes at the beginning of 1930 there were approximately 84,000 electric refrigerators, 210,000 ranges, 1,260,000 irons, 800,000 radio sets, 350,000 vacuum cleaners, 560,000 toasters, 84,000 water heaters, 350,000 washing machines, and 70,000 fans. These electric appliances alone consumed during 1930 a total of over 908,000,000 kilowatt-hours of current.

The rapidity with which households take up new electrical devices is well demonstrated by one appliance—the radio. Although comparatively new, the radio has already graduated from the luxury class. In 1930 alone 223,228 radio sets were placed in service. These new sets consumed over 19,000,000 kilowatt-hours of electricity.

Each year electric power lines are being extended into rural communities, thus making electricity available, not only for lighting, but for home appliances and power purposes on the farm. In 1930 farm electric service was extended by 20 per cent., the largest gain in any single year. The domestic use of electricity is constantly increasing at a regular rate of about 14 per cent. per annum.

Industry continues to take advantage of the economies of electric power. Electric heat-treating furnaces in many plants are contributing factors towards higher quality products at lower costs. One of the interesting installations of last year was an electrically-heated drill furnace at a Northern Ontario gold mine. This furnace is installed 3,000 feet underground, and obviates the necessity of bringing the drills to the surface for sharpening.

—*Canada Week by Week.*

Famous Last Words

Overheard by T.J.B.

That ain't a cable, Bill! It's a tree root. Give me yer pick! . . . .

* * * *

I telephoned the substation to make this transformer dead . . . .

* * * *

No need to hold the ladder, Harry. I'll manage myself . . . .

* * * *

I've cleaned this gear for years without rubber gloves . . . .

* * * *

I don't believe that pressure gauge. The safety valve can't have stuck . . . .

* * * *

Weighs five tons, does it? Well, I expect this sling will hold. Hoist away . . . .

* * * *

She seems to be running very fast. Perhaps I'd better look at the over-speed trip . . . .

* * * *

Here's the water, in this petrol can . . . .

* * * *

I'll sit here and get a good view of the explosion . . . .

I can't be bothered to wear a safety belt. I've never fallen yet . . . .

* * * *

You don't need to take too much notice of these danger signs . . . .

Hae ain wi' me, mon . . . .

* * * *

—*Distribution of Electricity*

THE BULLETIN

Published by
HYDRO-ELECTRIC POWER COMMISSION
of Ontario

190 University Avenue
Toronto

Subscription Price $2.00
Per Year

The Winter Convention

THE Convention of the Ontario Municipal Electrical Association and the Association of Municipal Electrical Utilities at Toronto on January 27, 28 and 29 was outstanding, both as to attendance and as to the interest taken in the sessions. In arranging for this Convention, the endeavor was to provide subjects of interest and instruction to all of its members, matters pertaining to all utilities both large and small. One of the papers appeared in the January issue while the others will be covered by this and the March numbers. By a careful perusal of those papers utility officials will find much of assistance and instruction.

The paper on Stores and Stores Accounting, while descriptive of a system for a large utility, contains much that might be adapted to the successful handling of supplies in the smallest municipality. As was emphasized in the discussion, supplies mean money and should therefore receive the same careful protection and recording as cash.

The general practice in distribution work is continually changing. The paper outlining advancements in the art was very timely and gave an opportunity for discussion regarding changes in materials and methods.

Recognizing the fact that it is not always desirable or convenient to build transmission or distribution lines so as to avoid trees, care must be taken in the treatment of the trees so that their lives and utility will not be endangered or their appearance made unsightly. The instructions given in the paper on this subject are useful, not only to linemen but also to any citizen who may be required to care for or treat trees.

The address by the Honourable George Challies on "The St. Lawrence and Its Development" gave in concise form the history of the negotiations regarding the development of the St. Lawrence River and the progress that had been made toward reaching an international agreement. The address indicated the complicated nature of the negotiations which necessarily makes the progress

CONTENTS

Vol. XIX **No. 2**

February, 1932

towards realization of the proposed work very slow.

In the operation of an electrical utility as in any other business, provision should be made in the financial structure for both unforseen and anticipated expenses. For this reason it is customary to establish reserves. Various practices in establishing reserves for utility systems were fully outlined in a paper covering this subject.

The paper on "Ground Connections for Distribution Systems" showed that this subject had been carefully studied in the past and much had been done toward obtaining satisfactory grounds. Considerable work and experimentation still remains to be accomplished before a satisfactory answer will be obtained for all conditions.

In addition to the foregoing, which refer to A.M.E.U. sessions and a joint session of the O. M. E. A. and A.M.E.U. there was the annual meeting of the Ontario Municipal Electrical Association, the proceedings of which were reported in the daily newspapers.

At the Convention Luncheons and Dinner there were addresses by outstanding speakers. The address by Ellis Manning on "Adventures in Science" gave some interesting illustrations of how accidental discoveries in the electrical laboratory had been or are hoped to be applied to the benefit and use of mankind. Rabbi Eisendrath's address on "The Human Family" showed the dependance of the individual on mankind in general. Speaking of Palestine, Rev. John Inkster, D.D., saw in the return of the Jews to that country the beginning of the fulfilment of a Biblical prophesy.

The tours on the third day of the Convention provided an opportunity for the delegates to visit the laboratories and some of the more important terminal and distribution stations of the Hydro-Electric Power Commission of Ontario and of the Toronto Hydro-Electric System. A large number of the delegates took advantage of these trips and expressed themselves as well pleased with the efforts on their behalf.

Ground Connections for Electrical Distribution Systems

By A. G. Lang, Distribution Engineer, Electrical Engineering Dept., H.E.P.C. of Ont.

(Read before Association of Municipal Electrical Utilities at Toronto, January 28, 1932.)

GROUND connections are utilized, in conjunction with electrical circuits and equipment, for a number of reasons, but chiefly for the purpose of reducing the hazard to life and property.

In Distribution Systems, ground connections are applied to the primary circuit, the secondary circuit, metallic bodies in close proximity to electrical circuits and lightning arresters.

The intent of this paper is not to discuss the advantages and disadvantages of connecting to ground such circuits and equipment but (A) to indicate some of the hazards that are inherent in a distribution system, (B) to indicate also that certain of these hazards may be reduced by adequate ground connections, (C) to show that additional hazards may be introduced if ground connections are inadequate or are improperly installed, and (D) to discuss in some detail the fundamentals pertaining to the installation of adequate ground connections.

(A) Hazards.

The hazards mentioned herein, are well-known but may be reviewed briefly.

(1) It is the common practise to carry primary and secondary circuits in close proximity; in the case of circuits on pole lines this is done for the sake of economy; in transformers it is essential.

Due to mechanical or electrical failure from wind, sleet, electrical storm or other cause, the primary circuit may come into contact with the secondary circuit.

Unless some provision is made to prevent an abnormal rise of potential in the secondary circuit, any person in contact therewith, or in contact with metal fixtures or conduit enclosing it, may be in danger of his life.

(2) Very similar to the above is the accidental contact between primary circuit and transformer case, either from within the transformer or without; the primary circuit may make accidental contact also with other apparatus such as metal conduit, street lighting fixtures, cut-outs and other metallic bodies which are normally non-current carrying.

Without proper preventive measures, personal contact with such apparatus may have fatal results.

(3) Accidental contacts between secondary circuits and metallic bodies such as mentioned above, present hazards less severe, but even so may cause fatal results, if not from electrical shock, possibly from accident consequent upon a slight shock.

Certain ever-present hazards which

are encountered in the daily routine of the electrical worker may be reduced by sound construction and ample clearances; and the known danger is usually carefully avoided.

The hazards listed above are in a different classification. The lineman on the pole or the child in the home reaches out and touches something which he has touched again and again. He assumes that it is safe. If any reasonable steps can be taken to keep it safe, those steps should be taken.

(B) Reduction of Hazards

The elimination of all hazards in an electrical distribution system is an impossibility. On the other hand we should do everything possible to reduce the number of hazards and to reduce the degree of hazards that cannot be eliminated by practical means.

If the existing regulations and approved standard practices are observed, a definite degree of safety is assured. Regulations usually cite minimum requirements, however, and that fact should be kept in mind rather than the idea of striving merely to meet those requirements.

The difficulty of measuring the resistance of a ground connection has in the past been a hindrance to a knowledge of actual conditions and to the enforcement of some regulations. Recently this situation has been altered by the development of a suitable type of instrument using a simple and easy method of measurement. You can now measure the resistance of a ground connection easily and with a great deal of certainty and accuracy. There is no longer an excuse for not knowing the resistance of any ground connection on your system and the thought to be stressed here is that knowledge of actual conditions will bring a realization of the hazards connected therewith.

(C) Hazards Introduced by Inadequate Ground Connections

Ground connections may be inadequate by reason of high resistance values or because of unsuitable materials or methods of installation or poor workmanship.

The installation must be adequate when installed and such that it will remain adequate. Only by periodic inspection and test can any assurance be had that it will remain adequate.

One example will be sufficient to indicate a possible hazard brought about by improper grounding where no hazard previously existed. If a ground wire be carried down the side of a pole to an earth connection, and left exposed to contact by the public, under certain conditions the exposed wire will present a dangerous hazard. It is particularly essential to guard against a break in the ground wire or imperfect connection to the ground rod.

(D) The Installation and Characteristics of Ground Connections.

One essential feature of a ground connection is that it shall have an adequately low resistance.

The resistance with which we are concerned may be divided into three parts.

(1) The resistance of what is commonly called the "ground wire" which connects the buried electrode to the distribution circuit or metallic body which may present a hazard.

(2) The resistance of the buried electrode itself.

(3) The resistance of the soil.

There is also the resistance in the actual connection of the ground wire to the distribution circuit or metallic body and in the connection of the ground wire to the buried electrode. These connections are of vital importance but present no difficulties if proper methods are applied, in which case their resistance may be considered as negligible.

There is also "contact resistance" or the resistance between the surface of the buried electrode and the soil in contact therewith. This resistance also is negligible for clean metal in firm contact with soil.

Of the three more important parts of the resistance mentioned above the first can be controlled to a satisfactory degree in most cases. The ground wire should be short and of ample cross section, for both mechanical and electrical purposes.

The resistance of the second, the electrode, will be negligible for the electrodes in common use.

The resistance of the third, *i.e.*, of the soil itself is the one which presents the greatest difficulties due to the usually high resistivity of the soil, which varies greatly in different locations and under different conditions of temperature and moisture in the same location.

"To illustrate briefly how the resistance in the earth is distributed about an electrode we may take a simple example. We will assume that we have a soil of uniform resistivity in which is buried a hemispherical electrode with its convex surface downward and its plane surface flush with the surface of the ground. If very thin shells of uniform thickness are marked off concentrically with such a hemisphere their mean areas will vary directly as the squares of their radii and hence their resistances will vary inversely as the squares of their radii. Any part of the total resistance to flow of current away from such an electrode can be exactly stated by taking the sum of the resistances of the shells from the surface of the hemisphere to the desired distance.

"This inverse-square law which holds exactly for a hemispherically shaped electrode may also be considered as a rough approximation to the conditions as to distribution of resistance about any small electrode such as a driven pipe; that is, a large part of the total resistance is found near by. It should be added that if the soil, instead of being of uniform resistivity as assumed above, were variable, the foregoing simple case would not hold; the distribution of resistance would be more complex.

"The practical importance of the character of the distribution of resistance about an electrode buried in the earth appears in its effect on the potential gradient in the vicinity of the electrode when heavy current is passing from it. Actual measurements show that in the case of driven pipes about 90 per cent. of the total resistance is generally encountered in the first 6 to 10 feet; hence, the potential gradients on the earth's surface near the pipe may be high enough in the event of heavy current flow to cause a drop of potential between pipe and points within reaching distance of it great enough to be dangerous to human life."

The foregoing is an extract from a

paper published in 1918, by O. S. Peters, Assistant Physicist, Bureau by Standards. We consider it to be fundamental to an understanding of the problem.

Driven Terminals

The pipe or rod electrode driven into the ground is satisfactory for a large variety of uses and is generally the most economical form of electrode available, although in certain cases it may be necessary to employ other forms.

The desirable features of the pipe or rod are so numerous that we find them used very generally where an artificial ground is required. Very little ground space is needed, the article itself is cheap and the connection to it is easily made. Lengths up to 10 feet are driven with comparative ease.

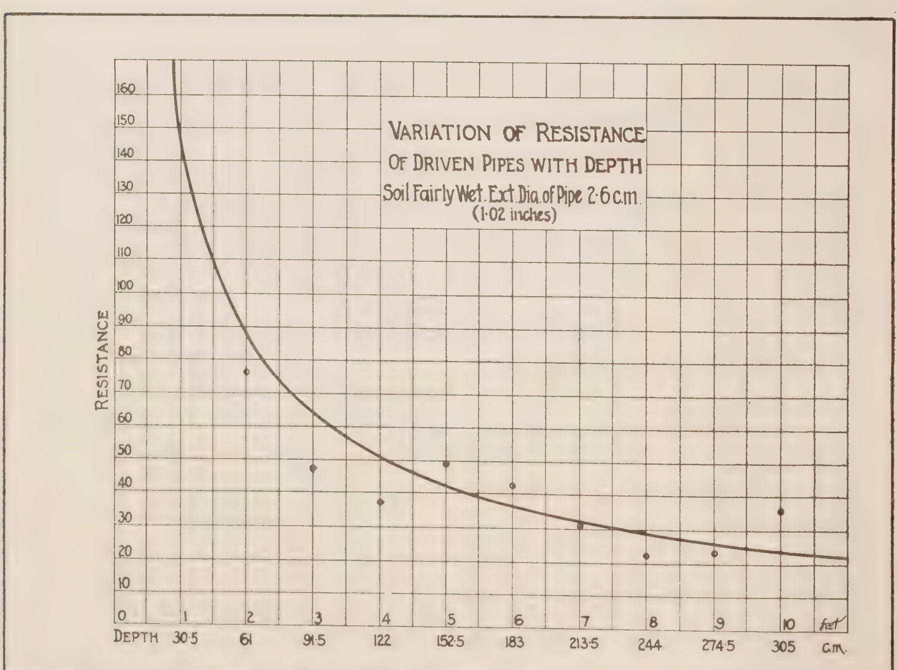
The electrical characteristics of a driven ground must be known in order to make efficient use of this particular type of terminal. A great deal of experimental work has been done to determine these characteristics by various organizations, notably by the Bureau of Standards, Washington.

The characteristics of greatest importance are—

1. Variation of resistance with depth.
2. Variation of resistance with number of rods in parallel.
3. Variation of resistance with contact area.
4. Variation of resistance with temperature.
5. Variation of resistance with moisture.

1. *Variation of resistance with depth.*

The curve below was calculated for a pipe of one inch outside diameter



driven in a uniform soil. Actual values observed for a similar pipe in a non-homogeneous soil are shown and occur on both sides of the calculated curve. Curves for different classes of soil we find to be of a similar shape.

It should be noted that the curve is calculated for soil of uniform moisture content and obviously in practice soil will not be found to be thus uniform.

Where the top soil contains less moisture than the soil at greater depth the resistance will decrease more rapidly than is indicated by the curve.

2. *Variation of resistance with number of rods in parallel.*

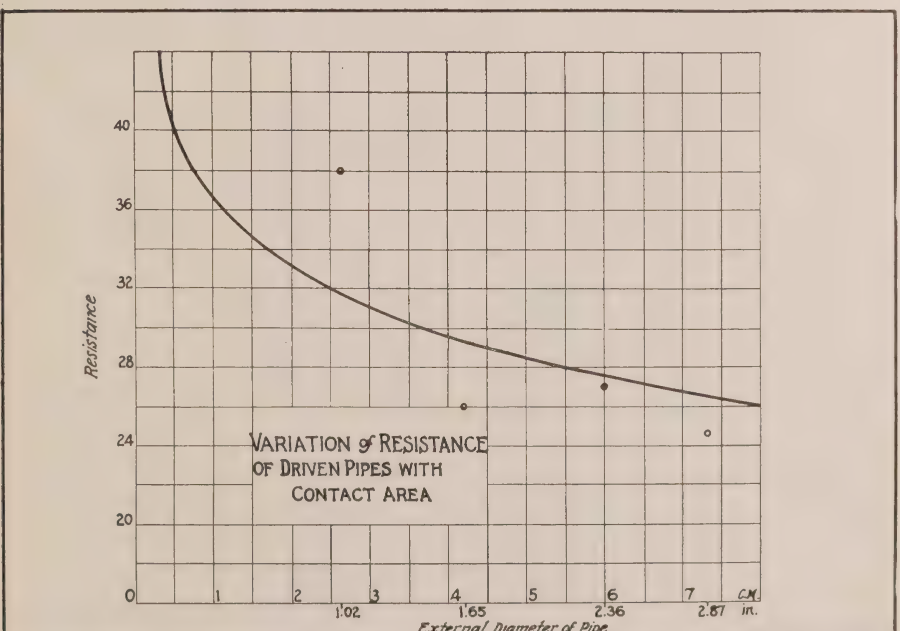
From the curve it will be seen that the resistance decreases rapidly at first and then more slowly as more rods are added.

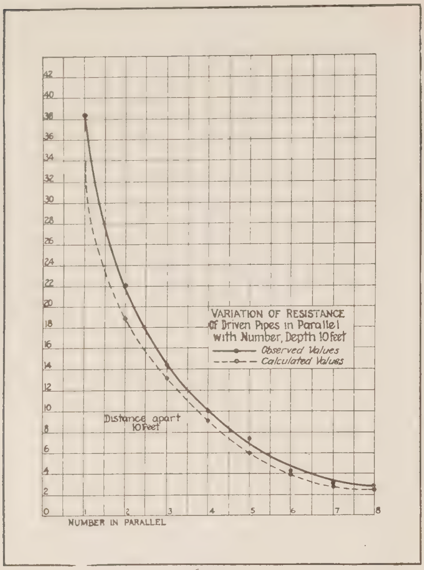
With uniform soil and rods at separation of 10 feet or more the combined resistance of rods in parallel will approximate the result by calculation using the ordinary formula for conductors in parallel.

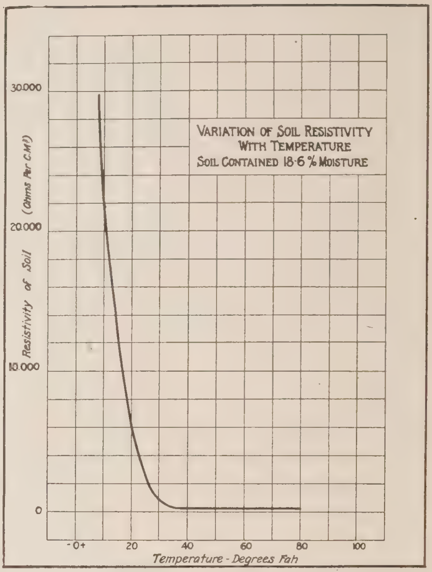
Our experience, gained in a large number of field tests, indicates that soil is far from uniform, even at points 10 feet apart, and no assumptions should be made, without checking by actual measurement, as to the effect of installing additional rods.

3. *Variation of resistance with contact area.*

This curve gives a great deal of assistance in choosing the diameter of electrode for any given conditions. Other factors should be considered such as ease of driving and the cost of the electrode itself. The standardization of a rod of moderate cost which will meet the resistance requirements for the more prevalent conditions is recommended. Where the required







standard of resistance is not met by one rod, another or several rods may be added. This is an economical procedure.

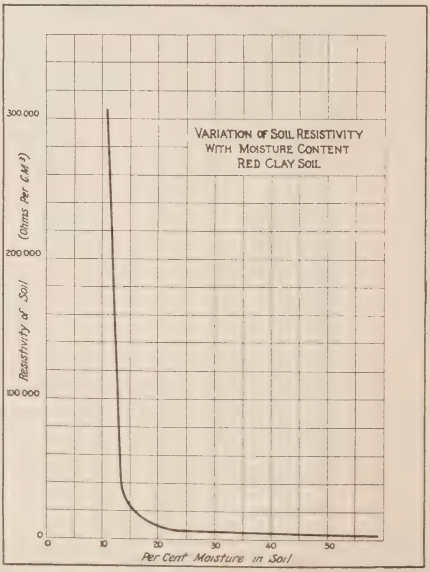
4. *Variation of resistance with temperature.*
5. *Variation of resistance with moisture.*

Seasonal variation is dependent wholly on the variation of the temperature of the soil and the variation of the moisture content of the soil. A study of the curves of variation of resistance with temperature and moisture reveals quite clearly the minimum requirements which in general, are essential to obtain low resistance values.

It will be noted that the resistance values increase sharply when the moisture content decreases below 15 per cent. and also increase sharply when the temperature falls below 32° fahr. Where low resistances are required throughout the year therefore, it follows that satisfactory results will not be obtained unless there is sufficient contact in soil containing adequate moisture below the frost line.

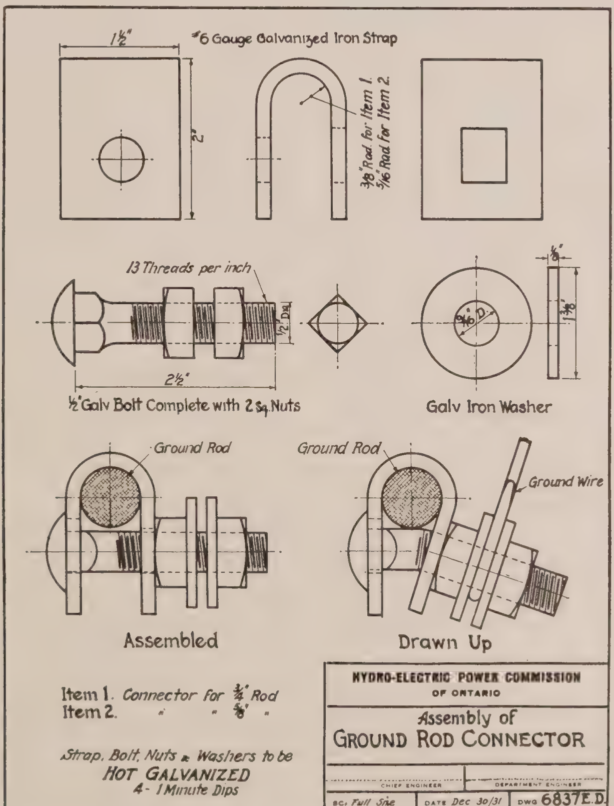
GROUND RODS

The standard electrode now in use for H.E.P.C. rural districts is a 10 foot rod of ¾-inch diameter and is



made of a steel used largely for reinforcing bars. It was found that this material drove well, had sufficient rigidity and did not mushroom under severe hammering. The point is conical and tapered for about four inches to quite a sharp point. This is found to assist in clay and heavy soils having no stones. For gravel or stony soils the rod is found to drive in more readily if the point is cut off with a pair of bolt cutters. The other end of the rod is hot-dipped galvanized for eighteen inches of its length. Rods of eight and six-foot lengths are also stocked to be used only where a ten-foot rod cannot be driven.

The connector for this rod is of the strap and bolt type as shown in the accompanying sketch. When drawn up, the strap and bolt deform thrusting the bolt into contact with the rod. This provides a high pressure contact. The deforming of the bolt also serves to jam the nut on its threads thus producing a locking effect. The ground wire connection is made between washers on the bolt and is secured by a second nut; this latter connection can therefore be opened at any time without disturbing the contact between the bolt and the rod. Before standardizing on steel as a material for a driven ground terminal we investigated a great many terminals of all kinds that had been installed for a number of years.



We failed to find any soil action that was serious and concluded that steel without any protective covering would perform quite as well.

Originally we took the precaution of using copper-faced washers on account of the dissimilar metals in wire and connector. Later this copper facing was abandoned and plain galvanized washers provided. This decision was reached after examining many connections made with the driving cap on a galvanized iron pipe. No provision for dissimilar metals was made with this arrangement in which a driving fit was made by the cap on the end of the pipe. This means of making a connection was not all that could be desired because of possible looseness consequent upon the driving. Some trouble has been experienced on that account, but trouble due to action between copper wire and zinc galvanizing is not in evidence. Since we have ten or twelve thousand terminals installed, a large proportion of which are pipes with the cap fitting mentioned above and since we have been practically trouble free from action due to the dissimilar metals, we consider that we may confidently expect a long life without copper facing the washers.

Ground Plates

The practice of using plates as electrodes is less common now than formerly as it is recognized that equal results can be obtained under average conditions with driven terminals at much lower cost.

Strip

Our experience with electrodes made of strip is very limited but we are now doing some work with it and with copper wire to obtain first hand information regarding its value under our climatic conditions. It is possible that an application might be found for it in rock country where the soil is shallow. Rods driven on a slant in the soil above rock have been found to give better results than those driven vertically probably due to the greater length of terminal entering moist soil nearer the rock. It would seem therefore that strip buried at the proper level might give the desired results by using a sufficient length. If frost penetrates to the rock it seems evident that an exceedingly great length of strip would be required.

Soil Treatment

Due to the fact that the greater part of the resistance from an electrode to ground is found in the immediate vicinity of the electrode, it is evident that any method which can be used to lower the unit resistivity of the soil will be most effective in the immediate vicinity of the electrode. Common salt is generally used for this purpose. It is easily applied and is cheap. The treatment shows results immediately with gradual improvement for perhaps a year or two. At some time it will be found necessary to replenish the supply of salt. This is the undesirable feature of the method.

The most important of the beneficial effects of salt is undoubtedly due to the fact that a solution of salt is much higher in conductivity than ordinary ground moisture. There are two other points which are not so well recognized in this connection.

In untreated soil the resistance

increases as the moisture content decreases. With salt-treated soil, as the moisture content decreases the concentration of salt in solution increases, which tends to reduce the resistance.

This action therefore counteracts to some extent the variation in resistance through wet and dry seasons.

Another characteristic is that the salt lowers the freezing point of the solution and lowers therefore the point at which the rapid rise in resistance with lowering temperature occurs.

Distribution System Problems

By W. R. Catton, Manager, Brantford Hydro-Electric System

(Read before Association of Municipal Electrical Utilities at Toronto, January 27, 1932.)

THIS paper is written primarily for the purpose of promoting discussion for the benefit of those of us from the smaller municipalities who, as you will agree, predominate in numbers.

It is felt that the larger municipalities have engineers for the express purpose of keeping their distribution systems in good order, while in the smaller places the operation of the system is largely centered in one or two men.

It is the job of each municipal man here to take power from the Hydro-Electric Power Commission and distribute it among his consumers, in the most efficient manner possible, with his lines offering a good appearance and guaranteeing as nearly as possible 100 per cent. service. Therefore, we are all aiming at the same end, although ideas may differ as to the best methods.

In this paper it is not proposed to deal with the 13,200 or 26,400 volt lines or sub-stations, but to begin at the load-side of circuit breakers feeding the primary distribution system.

In selecting the route for a pole line, it is important to consider the district through which this line is to be built and the probable future size and nature of load. Obstructions such as trees and other lines will be avoided where possible; most trees can be over-built, but the tendency to-day is to keep away from excessively high poles. Thirty-five or forty foot poles will eliminate much maintenance, and their location is of much importance. Care should be taken to avoid possible future driveways as well as present, and consideration for the wishes of the home owners opposite proposed locations may often be given by slightly varying the standard spacing. We should also use on the streets, poles that give the best appearance, and save the crooked or knotty poles for the lanes. If western cedar poles are not used then only straight eastern poles, well dressed, should be erected in residential districts. Most of us find that much criticism of the appearance of a pole-line is eliminated if we use a good shade of green paint.

The practice of guying poles varies a great deal, but if not properly done, leaning poles is the result, and a pole not standing straight is doubly conspicuous. Where possible, anchors should be such a distance from the pole that the angle between pole and guy wire will be not less than forty-five degrees. Otherwise strain will be increased, and additional strength requires to be built in. Poles should be protected by one of various guy wire plates now on the market, except that in some cases it is feasible to carry an eye bolt through the pole and through the centre of a secondary rack to which may be attached the guy wire. This eye bolt also serves very well where small primaries are dead-ended on double arms. Guy insulators should be at least eight feet from the ground line and capable of protecting against any voltage on the pole. A clearly visible guy guard should also be installed.

Cross arms, in recent years, have changed, both as to pin spacing and arm strength. The old four-pin arm so extensively used some time ago has only thirteen-inch pin spacing, and served fairly well on 2,200-volt ungrounded systems, but now that we are gradually changing over to 4,000-volt grounded neutral systems, better climbing and working space is necessary for safety's sake. The present Hydro-Electric Power Commission's standard six-pin arm used as a four-pin to accommodate 3-phase wires and the neutral, will give twenty-six inch phase spacing and the result minimizes line troubles.

In some places a common neutral for primaries and secondaries is used and is carried with the secondaries and not on the primary arm. We think that all arms on new construction and replacements for 3-phase primaries, regardless of whether they are 2,200 or 4,000 volts, should have twenty-six inch spacing. Where separate power and light primaries are used, the power should be on top, as the light primary is worked on more than the power. Dead-ending heavy primaries on standard wood pins has been found to be poor practice, and a heavy clevis with a spool-type insulator of fairly recent design appears to be the answer to dead-ending problems. Where properly installed with through bolt and double arms, the job is complete in every respect.

The position of secondaries on poles is of great importance, and it has been found by some of us that the lower we can place the secondary brackets the better, because pole-sway is minimized. It is also suggested that the appearance of services is better than when dropping from a high position. Secondaries dead-ended on standard heavy type spool racks make a permanent job and will give the minimum of trouble and maintenance; of course it is assumed that all secondary brackets are bolted in position, and if erected say twenty-three feet from the ground line, will clear under all large trees. The problem of clearing secondaries through low trees is not great, and usually very little trimming and a good grade of wood moulding will solve the problem.

Services, unless properly constructed, are unsightly and also require much maintenance, especially as they are subject to strain through pole-sway, tree limbs, sleet, etc. A fairly recent development brought

about possibly by these conditions, is the service cable. It consists of two or three wires encased in a common weather-proof sheath, and while it may cost more than the present service, the lack of maintenance plus neatness will justify its greater use in the future. We have all no doubt experienced the inconvenience of connecting to a service conduit at the rear of a house—placed there by the wireman because of competition in prices of house wiring. The installation of the service would be simplified if definite rules were laid down by the Inspection Department. If service pipes were erected as near the front of the house as cellar-conditions will allow, we would be able to improve the neatness of services to a great extent. In some municipalities the wiring contractors know that the utility must be consulted about the location of outlets. In other places a specific distance from the street-line has been fixed, beyond which the cost of the service must be paid by the consumer.

The size of conductors has usually been determined by "rule of thumb", but we believe that considerable economies in operation could be effected through more careful checking of actual conditions. Regulation may also suffer through the use of wires too small, and a common example is a 3-wire secondary with a small neutral and carrying an unbalanced load. Where the drop in the neutral exceeds that of either of the other two wires, the result is high voltage on one side and low voltage on the other.

Some of the reasons for the general use of weather-proof wire as against bare wire, will now be given:—

(1) While it is definitely understood by the men in the field that weather-proof covering of conductors is not to be considered an insulation against shock, there has been a certain amount of protection and accident prevention due to the fact that wires, and particularly secondary lines, were weather-proofed. This is undoubtedly true on pole-lines where circuits are numerous and of varying voltages. Very often secondary wires under 600 volts are supported on grounded or partially-grounded structures—steel poles, concrete poles, etc.,—and men who have had experience with these structures do not recommend the stringing of bare wire.

(2) Many cases of falling primary lines across secondary lines have been experienced where damage has been negligible through the presence of weather-proofing. This is particularly true in connection with street lamp losses, which have been reduced by use of weather-proof conductors.

(3) Many utilities insist that a ground wire attached vertically to a pole, be covered with wood moulding, and it would not appear consistent to permit a grounded bare neutral wire on a Cross-arm located at the feet of a lineman working on a live primary line immediately above.

(4) Very often it is necessary to string lines above existing wires, and it is obvious that weather-proofing affords considerable protection against grounding and short-circuiting.

(5) Weather-proofing prevents leakage where run through trees and foliage, and in turn prevents loss,

saves trees, and reduces radio interference.

(6) Bare wires would necessarily increase the horizontal and vertical separation between conductors at supports, thereby reducing the pole and cross-arm capacity and necessitating changes in standard spacing, on racks and brackets, increasing the cost of these materials.

Do we give the distribution system transformers the thought and care they deserve? We have had a number of good papers dealing with the care, testing, and connection of transformers, and nothing new can be added here, except to emphasize one connection which offers a big advantage. Where two transformers are erected together to handle a certain load, there is the choice of either banking these, or of connecting each secondary for 110 volts and putting the two in series. In the former case, a heavy over-load blows the weaker fuse. The other transformer immediately picks up the load of both and its fuse in turn blows, thereby putting an interruption on the district. In the second case, one transformer may be taken out of service by its fuse, but this does not affect the other, which continues to supply appliances on that side of the 3-wire secondary. In addition, the banking of transformers requires two which are identical in their characteristics, whereas the series connection may be made between any pair and even their size may differ, if the load unbalance is such as to allow it. Transformers constitute one of the major items in capital expenditure on your distribution system, and because of this a record of each transformer, with its date of purchase, make, size, voltage, etc., should be tabulated. A definite routine of measuring load and balance during the summer as well as winter, will largely eliminate damaged transformers, except through lightning, and will save money tied up in idle capacity. In many places it would also save money paid as power factor penalty. Standard transformers are rated 125 per cent. load for two hours, but without going to the expense of obtaining a graphic chart showing the record of each transformer, it is not easy to fix on the safe maximum load. In the final analysis it must be remembered that it is the temperature of the winding which governs, and a ready indication of this condition, if it could be made available cheaply, by the manufacturer, would be of great service to the Municipalities.

Because of the large increase in domestic loads, and the corresponding increase in the number and size of transformers as compared with a few years ago, transformers are no longer erected near the top of the pole. They are now mounted low on the poles—in most cases not more than twenty feet from the ground. This also makes possible a neat connection to the secondaries. Then when it is necessary to move a transformer, the job is simplified by its low position.

To-day, dependability is required of electrical service and the transformer cut-out is a protective device whose function is not merely to save from harm the transformer, but also to limit the area involved when trouble occurs. It is generally recognized that the expulsion type is at present the best inexpensive means of accomplishing these results. To gain

the maximum dividends on the investment, and even to be sure that their installation will not defeat the purpose for which they are intended, care should be exercised in their selection and location on the pole. Those on the market to-day divide generally into two main classes—the door type and the barrel type. Under these two headings there are a number of varieties from which the purchaser may select. The degree of service and reliability obtained from these cut-outs will depend upon the quality of the various items entering into them, such as the fibre tube, the fuse element, the contacts, and the housing. The safety with which they are operated will depend to some extent on their construction as well as the location on the pole, and the use of a suitable switch stick. While the latter is no doubt an advantage in keeping a man away from the cut-out when it is being opened or closed, yet the difficulty of always providing it when needed, causes many Municipalities to forego its use. Cut-outs are also used to sectionalize lines, but their capacity is limited to a point where their use, except on branches, becomes only an invitation for interruptions to occurr. In this connection it is suggested that a suitable signal, whereby linemen could readily find the source of trouble, thereby leading to a quick restoration of service, would be of service to the Municipalities.

In some municipalities, the joint use with the Bell Telephone Co. of a pole-line either through joint ownership or merely joint use, has been found beneficial. The re-action of the public to this program has also been one of appreciation, in that it practically reduces the number of poles on the street, to one half. The only serious disadvantage is the matter of a suitable location for transformers, because the Bell Telephone Co. refuses to allow its men to climb past a transformer. This means either locating the transformer high on the pole or putting a special pole to one side, or placing the transformer underground. The latter arrangement is most desirable except for the cost. It offers a more or less new field on which the manufacturers might concentrate. On streets where joint lines are not in use, services crossing the street might very well be attached to the telephone pole tops, with benefit to both parties. The services are then clear of the telephone lines at all times and put less strain on the bracket at the house; it also has a guying effect on both pole lines.

It is to be expected that there will be many important developments in the art of distribution within a few years, and it is probably one of the important duties of the men charged with the operation of such a system, to be conversant with what is going on about them, and to be building towards what they think conditions may require of them at some future date. For example:—Two of the cities represented here have begun a low-voltage network system. It may be said that that is only for the densely loaded areas, but who will predict what the density and the demand for non-interrupted service of residential consumers may become? And who will deny that one transformation has its advantages as

against two? In the meantime, for the lighter loaded areas, there is the medium voltage network with all the advantages claimed for it, in addition to improved service.

It is felt that we will all benefit greatly if the discussion arising out of this paper can be keen, and there are many topics which have been omitted from the paper that can be brought out in the discussion.

The engineers of London, Chatham, and St. Thomas have co-operated with the writer of this paper, and they feel, as he does, that *their* problem is *your* problem, and it is to our mutual advantage to help one another in this more-or-less local condition of extremely heavy domestic loads which exist in Ontario.

Charles T. Barnes, Oshawa

Mr. Charles T. Barnes, General Manager of the Oshawa Public Utilities Commission died suddenly at his home in Westmount, a few minutes before noon on Thursday, February 18. 1932, at the age of 54 years.

Mr. Barnes was one of the most highly respected City Officials of Oshawa and enjoyed the most complete confidence of the Public Utilities Commission together with the respect of the employees of the Local Commission.

Coming to this country from England, he took employment with the Toronto Power Co., with which Company he held various positions. In 1905 he joined the staff of the Toronto Street Railway, where he remained till 1909, when he was sent to Niagara Falls on the Electrical Development Company staff. In 1913 he was sent to London to take charge of the London Electric which was a subsidiary of the Toronto Power Company. In 1918 he was returned to Toronto, and after the sale of their properties by the Toronto Power Co., was taken over by the Hydro-Electric Power Commission in 1920. Here he was employed at the Head Office in connection with the Georgian Bay System. In 1923 he was sent by the Commission to Oshawa to manage the electric and gas utilities in that city, which were then the properties of the Government and under the administration of the Commission. He was also in charge of the rural extensions out of Oshawa, which under his management have since grown to a considerable extent. In 1929 when the Local Utilities were purchased by the City of Oshawa from the Government, Mr. Barnes, together with the staff under his charge, became employees of the Corporation and he was placed in charge of the management of the Local Utilities. Later, the Water Works Utility was also placed under his charge. Mr. Barnes' wide knowledge of technical engineering matters made him a valuable man to the Oshawa Public Utilities Commission and his loss will be greatly felt.

His pleasing personality gained him a large circle of friends, both in Oshawa and in the electrical field throughout the Province.

Mr. Barnes is survived by his wife, three sons and one daughter, to all of whom are extended sincerest sympathy.

The funeral was at Oshawa on the afternoon of Saturday, February 20th.

Stores and Stores Accounting

By J. M. Prentiss, Stores Auditor, Toronto Hydro-Electric System

(*Read before Association of Municipal Electrical Utilities at Toronto, January 27, 1932.*)

IT is only within quite recent years that a Stores Department in any large organization has been recognized as of sufficient importance to receive attention. Now, however, this Department is one of the family. An Executive officer of one of the leading Southern railways says:

> "The old heads considered the Stores Department an irresponsible youngster—or, if they condescended to consider it at all—the majority of employees, from laborer up, voiced their opinions their Departments were charitable in feeding this goat. It would be conducive to better results to acknowledge the fact that the Stores is a vital and necessary member of the family. Stores is to an organization what the Commissary Department is to an army—and just as sure as the army fights on its Commissary so does the organization progress and function on the ability of its Stores to procure, store, and deliver the materials needed and have them when needed."

A Stores Department is just another sort of Cash Box. The materials stored there are purchased with cash against the time of need—ready to be requisitioned by the operating departments. They are an investment based upon the plans laid out by the Engineers. It will readily be understood why these materials should be carefully handled—kept in a safe place—in an orderly manner—by experienced employees—and strictly accounted for—just as you would care for your cash and negotiable funds. The Stores should be kept in a substantial building—which can be locked up against theft and unauthorized withdrawal.

This naturally raises the question as to what officer should have control of the Stores Department. As the material is a cash investment held for future use by various persons—and the receipts and issues must be carefully accounted for in the accounts it would seem but natural the Stores Department would be under the jurisdiction of the Comptroller or a similar official—whatever his title may be. As this Department is operated for the convenience of the Engineering departments and operated outside the Accounting Department it is under the direct supervision of a Storekeeper who reports to the Chief Accounting Officer. Like everything else—the best Stores system will fail unless the Storekeeper has the proper qualifications. He should be honest—and have good judgment.

The equipment of the Stores Department should be such that materials can be stored neatly in proper classifications. Steel shelving is recommended because it lends itself

to economy of space and the bins can be enlarged or reduced in size very easily and quickly by the men in charge. The bins should be labelled with trade names of materials contained therein as well as with a stock reference number linking up the Storeroom with the office stock ledgers. As the fundamentals of all Stores systems are the same, we shall describe in this discussion the system of a large Stores. The smaller Stores can adapt a system by combining or omitting certain features of the routine. The equipment and staff will be governed also by the size of the plant.

The Staff organization in a large Stores would consist of Storekeeper—Stores Superintendent—Section foremen, Receiver, Shipper, Laborers, Office clerks. The Storekeeper would have supervision of the entire department—having his time fully occupied with the maintenance of stock—contact with Engineering departments as to requirements—placing of purchase requisitions with the Purchasing Department—disposal of obsolete material—follow up on slow moving stock and supervision of office records for the Accounting. The Stores Superintendent would direct the warehouse work—have charge of the warehouse staff—and generally keep things moving for efficient service to those departments served by the Stores. The stock would be classified into sections, say—Stationery, Overhead, Underground, Bars, Pipe, Lumber and Cross Arms, Transformers and Oil, Weatherproof Wire, Miscellaneous Hardware, Lead Covered Cable, Poles, Appliances and Lamps. Each section would be in charge of a Section Foreman responsible for the storing of the material and filling of requisitions for issue. These foremen in time become thoroughly familiar with their stock and are a real asset to the organization. The Receiver is in charge of the Receiving Room into which is taken all materials delivered to Stores by Supply Houses and Foremen. He checks and counts against Purchase Orders and Foremen's Credit Slips and passes on approved material to Stock room foremen who again check and count into the bins and enter upon their Bin Cards. This man must be just as capable as a Receiving Teller. The Shipper has charge of the Shipping Room through which all material passes from Stores. To him material is sent from the different Section Foremen when they fill the requisitions sent in by the Engineering Departments. These materials come to the Shipping Room with the Requisitions covering. The Shipper checks for right materials and count. He gets signature on the Requisitions from the drivers and he, too, must be as good as a Paying Teller. The laborers are a mobile group available for whatever work is most pressing. The Office clerks keep the records, price the requisitions, post the receipts and issues, and compile reports for the Accounting Department.

Let us here briefly consider the functions of a Stores Department.

1. It receives materials which have been purchased from Supply Houses on Purchase Orders.

2. It receives from Construction foremen materials which have been withdrawn from Stores in excess of

HYDRO-ELECTRIC SYSTEM

PURCHASE REQUISITION

№ 48199

TO PURCHASING AGENT·

DATE............................193....

Kindly have the following delivered to the Stores Dept.

ORDER No.	QUANTITY	ARTICLES	LOT No.	SUPPLY TICKET	CODE

TYPED BY.................... APPROVED BY.................... SIGNED....................

Fig. 1—Purchase Requisition.

the requirements of each authorized job.

3. It receives from these same foremen materials from equipment taken out of service—returns to stock of material fit for re-use and scrap that is unfit to go into service again.

4. It issues upon properly authorized requisitions material for construction of new work, repairs and maintenance, and material (usually appliances and lamps), sold to customers.

5. It keeps such records of these operations as will enable the accounting department to distribute the charges and credits correctly. Records must also be kept of the stock on hand.

A large employer of labor once said he always had three gangs of men—one gang coming, one gang working, and one gang quitting. So in Stores we have material coming in, material in stock, and material going out. In considering the Forms used in Stores accounting we can consider these three phases of Stores operations.

Purchase Requisition. (*Fig. 1*)

When any material is required for Stores stock, the Storekeeper makes a Purchase Requisition in triplicate showing description—quantity and any other information necessary for the guidance of the Purchasing Agent. One copy goes to the Purchasing Agent—one copy to the head of the Department which will use the material and one copy filed in the Stores Office. When Purchase Order is issued two copies are received by Stores and the Order number is posted on the Stores copy of Purchase Requisition.

Purchase Order. (*Fig. 2*)

Is issued by the Purchasing Agent and two copies received by the Storekeeper—one for file in Office and one for the Receiver to be used by him in checking the material when delivered to Stores. From this copy the Receiver knows just what should be accepted and how much. On some special equipment it is customary for the Receiver to have a representative from the Engineering Department inspect the shipment and sign an Inspection Slip. A copy of the Purchase Order goes also to the Accounting Department as it shows the quantities ordered and the prices to be paid and terms of payment. No departure should be made from these prices without the written approval of the Purchasing Agent. The Accounting Department receives also

HYDRO-ELECTRIC SYSTEM

To

PURCHASING ORDER No. E 89019

P.R.

PLEASE SHIP VIA (..................) the following, AS PER CONDITIONS ON THE REVERSE HEREOF.

QUANTITY	ARTICLES	HYDRO LOT No. AND CODE	PRICE	AMOUNT
	Please Comply With Conditions On Reverse Side Hereof			

If the above is purchased "F.O.B. and the System has to pay the Freight the System will include in their Re-charge an extra amount to cover cost of clerical work involved.

HYDRO-ELECTRIC SYSTEM

Purchasing Agent

Fig. 2—Purchasing Order.

from the Storekeeper (as noted later) a copy of the Receiving Slip showing quantities actually received on the Purchase Order. By checking these against the invoice for the shipment the Accounting Department is enabled to approve the Invoice for payment.

Receiving Slip.

The Receiver prepares for the Storekeeper a Receiving Slip (Fig. 3) showing Purchase Order number, name of Supply House, date of receipt of goods, quantity and description of goods received. This is made in quadruplicate—copies distributed as follows—

1. Stores Office, where it is checked with the copy of Purchase Order and Invoice (when received). Price is entered and extension shown and posted in stock ledger.

HYDRO-ELECTRIC SYSTEM

INVOICE AUDIT DEPT. COPY

№ 205614

ORDER NO. ....

RECEIVING SLIP

SHIPPER.................. DATE.................. 193....

QUANTITY	MATERIAL	LOT No.	SUPPLY TICKET NO.	COST

INSPECTION SLIP No..................

POSTED BY..................

SUPPLIER'S D.S. No..................

CHARGED ON INVOICE No..................

RECEIVED BY.................. DUTY

COMPLETE / PARTIAL } SHIPMENT..................

RECEIVER

STOREKEEPER

Make any further notations regarding condition of case and short or damaged material on other side.

Fig. 3—Receiving Slip.

№ 77992

HYDRO-ELECTRIC SYSTEM
CREDIT SLIP

DATE

ORDER	D.R.	CREDIT TICKET

TO STORES DEPT.
FROM (DEPT.)............ FROM (LOCATION)............

QUANTITY	MATERIAL	QUANTITY ACCEPTED	LOT No.

SIGNED .... FOREMAN
SIGNED .... RECEIVER
SLIP No.

Fig. 4—Foreman's Credit Slip.

2. Accounting Dept.—Stores enter Invoice number for convenience of Accounting Dept. to identify so that invoice may be approved for payment and charged to Stores Account.

3. Purchasing Agent—to close out Purchase Order.

4. This copy remains with Receiver.

This briefly shows the routine for ordering—receiving and recording material purchased for Stores and furnishes to the Accounting Department the information necessary for charging Stores Account.

Foreman's Credit Slip. (*Fig. 4*)

When Foremen have overdrawn material or have taken material out of service it is entered by the Foremen on the Foreman's Credit Slip showing quantity and description and other information necessary for preparing the Credit Ticket which follows for accounting purposes. This material

№ 72167

HYDRO-ELECTRIC SYSTEM
FOR USE OF EMPLOYEES ONLY
CREDIT TICKET............

Date............193

To Stores Department: Please receive the following:—
From............
Address............

CREDIT AS FOLLOWS:

JOB ORDER No.	WORK ORDER No	ACCOUNT No	FOREMAN'S CREDIT SLIP No.

Approved Signed

PRICED BY	EXTENDED BY
CHECKED BY	
	POSTED

QUANTITY RETURNED	DESCRIPTION OF MATERIAL	LOT NO	QUANTITY RECEIVED TO BE FILLED IN BY STOCK CLERK	UNIT PRICE	PER	AMOUNT

ABOVE GOODS RETURNED
............193............ A.M. P.M. Signed............ + %
Credit Slip checked by............

Fig. 5—Credit Ticket.

is sorted and counted by the Receiver and returned to stock or scrapped as found advisable.

Credit Ticket. (Fig. 5)

The Foreman's Credit Slip is checked and from this is prepared what is known as the Stores Credit Ticket, on which is shown the Foreman's Credit Slip number and the account number which is to receive credit for the value of material returned. This material is listed as to quantities and description and three copies are priced and extended. One priced copy is filed in Stores, one copy goes to Engineering Department, and one copy is for Accounting Department. One important thing to note in pricing Credit Tickets is that prices should agree with those on the Requisitions charging the material out if possible. Where Requisition number is not shown on the Credit Ticket, current prices are used.

Stores Requisition. (Fig. 6)

We come now to the issues of material from Stores. The Engineering Departments have their work laid out for the foremen and as each job comes along a Requisition is prepared for the material necessary to do that job. This is based on estimates. This requisition is known as a Stores Requisition (Fig. 6). It is signed by the clerk who prepares it and approved by the head of the Department. It shows the name of the Foreman who is to receive the material and shows the account, Job Order or Work Order number which the Accounting Department has designated. It is made in sextuplicate. The sixth copy is retained by Department issuing. The other five go to Stores. The form is serially numbered. Upon reaching Stores one copy is filed under serial number as master copy. The other four go to the warehouse foremen who assemble the material called for, showing opposite each item the quantity supplied and the Lot or Stock number. We have mentioned before that this number is the safety link between Ware-

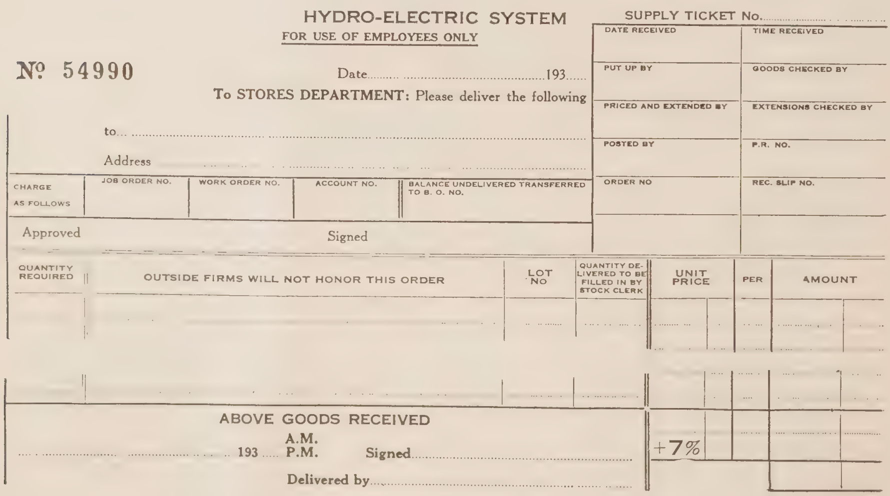

HYDRO-ELECTRIC SYSTEM
FOR USE OF EMPLOYEES ONLY
SUPPLY TICKET No.
№ 54990
Date 193
To STORES DEPARTMENT: Please deliver the following
to
Address
DATE RECEIVED
TIME RECEIVED
PUT UP BY
GOODS CHECKED BY
PRICED AND EXTENDED BY
EXTENSIONS CHECKED BY
POSTED BY
P.R. NO.
ORDER NO
REC. SLIP NO.
CHARGE AS FOLLOWS
JOB ORDER NO.
WORK ORDER NO.
ACCOUNT NO.
BALANCE UNDELIVERED TRANSFERRED TO B. O. NO.
Approved
Signed
QUANTITY REQUIRED
OUTSIDE FIRMS WILL NOT HONOR THIS ORDER
LOT NO
QUANTITY DELIVERED TO BE FILLED IN BY STOCK CLERK
UNIT PRICE
PER
AMOUNT
ABOVE GOODS RECEIVED
193 A.M. P.M. Signed
Delivered by
+7%

Fig. 6—Stores Requisition.

house and office ledgers so that the entry in the ledgers is for the stock actually issued. As the stock man fills each item he enters the quantity in the issued column on his Bin Card and deducts from quantity in On Hand column showing Balance on hand. He shows the Requisition or Supply Ticket number on his package of material and when the Requisition is filled the four copies go with the material to the Shipping Room where it is all checked by the Shipper against the Requisition and placed in the bin set aside for the particular Foreman who is to get it. When the material is taken by or delivered to the Foreman the four copies are signed and the fourth copy taken by the Foreman. The other three go to the Stores Office. Here they are checked off the register as being completed. They are priced and ex-extended, values totalled and the Stores Charges, a fixed percentage, added, and go to the Stock Ledgers to be posted as to quantities issued and value. Balances of quantities and values are carried in these Ledgers thus giving a perpetual inventory which is of great importance in the event of a fire loss in the Warehouse. Needless to remark these Ledgers are kept in a fire proof vault when the office is closed at nights, Sundays and holidays. The prices are cost, including duty, if any, but we buy, Made in Canada, if at all possible. We also buy at a price delivered at Stores so that transportation is included in price on Purchase Order. The percentage added for Stores Charges includes all overhead costs of maintaining the Stores Department and based on the annual turnover for the previous year. By adding this to each Requisition Supply Ticket the costs are evenly distributed to the work as carried on. The three copies priced are separated, one going to the Accounting Department, one filed in Stores and the third going to the Department from which it originated. For the convenience of the Accounting Department these priced copies are listed on a Distribution Sheet under the various headings to simplify posting. The Stores Charges are credited to Stores Expense.

You will note that before the Stores Requisition is issued by the Engineering Department, the Accounting Department has been consulted as to how the material is to be charged and when the Stores send through the completed priced copy the posting is merely a matter of routine.

Delivery Slips. (*Fig. 7*)

When Stores have occasion to send out material other than on a Stores Requisition use is made of a Form known as the Delivery Slip. This shows the destination, the quantity and description, the reason for delivery and whether it is to be replaced by other material, or to be repaired, or whether Credit is to be received. The Supply House may have sent in material other than that ordered, or more than the Order calls for, or all or part of the shipment may be damaged, in which event there will be a replacement or a Credit. Material may be sent out for repairs in which case there will be a Purchase Order supporting.

There are five copies of this Delivery Slip—

1. Vendor.
2. Stores Office for follow-up.

HYDRO-ELECTRIC SYSTEM

DELIVERY SLIP

VENDOR'S COPY

D. S. № 25082

Invoice No.

193 R. S. No.

To

We have returned to you by

the following goods received on OUR ORDER No.

Reason for return

REPLACE
REPAIR
CREDIT
SIGNATURE

QUANTITY	ARTICLE	STOCK NO.

Received the above in good order and condition (date) 193

Delivered by Received by

Fig. 7—Delivery Slip.

3. Accounting Department.
4. Purchasing Department.
5. Master copy for Warehouse or Office File.

The Accounting Department is guided by the information shown on the Form in their handling of these transactions. If a replacement is to be made they may hold payment of the invoice or if only part is involved they may recharge that part and pay the balance. If a credit is called for, they may recharge or hold in follow-up for receipt of the Credit invoice. If it is a repair they will treat as any other order and pay when Stores advise completion of the work and receipt of material. In

№ 81994

Hydro-Electric System

TRANSFER OF MATERIAL

Accounting Dept. Credit

DATE 193

TO STOREKEEPER

The following material has been transferred from WORK/JOB Order No. to WORK/JOB Order No.

APPROVED SIGNED

PRICED AND EXTENDED BY
CHECKED BY
ENTERED BY

TO BE FILLED IN BY DEPARTMENT TRANSFERRING

QUANTITY	ARTICLES	PRICE	UNIT OF PRICE	AMOUNT
		+ 7 %		

Fig. 8—Transfer Form.

the return of Drums or Reels this form is used. As these Delivery Slips are signed by the party receiving the material listed, they act as receipts.

Transfers. (Fig. 8)

Material taken from Stores for a particular job and charged to that job, may be used on another job. When this is done the Foreman lists such material and reports it to the Engineering Department. There a Transfer is prepared on which is listed the material and asks that the value be transferred by the Accounting Department from the one job to the other. There are five copies of this Transfer, which come to Stores to be priced. If the Transfer shows the original Requisition Supply Ticket on which the material was taken out, the prices are the same but where this information is not shown the current prices in the Stock Ledgers are used. After pricing, the five copies are distributed as follows—

2 copies to Accounting Department (Credit copy and Debit copy).

1 copy filed in Stores.

2 copies to Engineering Department issuing.

For convenience of the Accounting Department again Stores list these Transfers on Distribution sheets.

Scrap Material is received by Stores and sorted into bins until sufficient quantities are accumulated to call for tenders. It is charged to Stores at estimated scrap prices and when sold the value received is credited to Stores, charged to a Job Order and this Job Order cleared by payments from the purchasers of the scrap.

We have dealt with the accounting

Date........................

HYDRO-ELECTRIC SYSTEM

STOCK NO........................

Material........................

....

Q'ty. ordered........................ Size........................

Bo't. of........................

Order No. .... | Am't. Rec'd. | R.S. or C.T. No.

MAX. STOCK ....

MIN. STOCK ....

ISSUED

S. T.	Q'TY.	BALANCE	S. T.	Q'TY.	BALANCE

Fig. 9—Bin Ticket.

for material in and out of Stores. We have now to consider the stock on hand. We have mentioned Stock Ledgers and Bin Cards. These constitute really two perpetual Inventories. The Bin Card is the more up-to-the-minute inventory because on it is recorded the material as soon as it comes into stock and as soon as it is issued from stock. The section foremen receive a new bin card with every new receipt of stock as purchased on a Purchase Order. This card is prepared in the Office. As soon as the stock shown on a card has been all issued the card goes into the Stock Ledgerkeeper and he checks it against his ledger entries to see that all receipts and issues are posted on both the card and the ledger sheet. In this way the two men are checking the work of each other. The bin card also shows the maximum and minimum amount of Stock fixed for each item. When the stock runs down the Section Foreman enters the item on the Material Required Sheet in his section and at the end of the day turns this sheet into the Store-

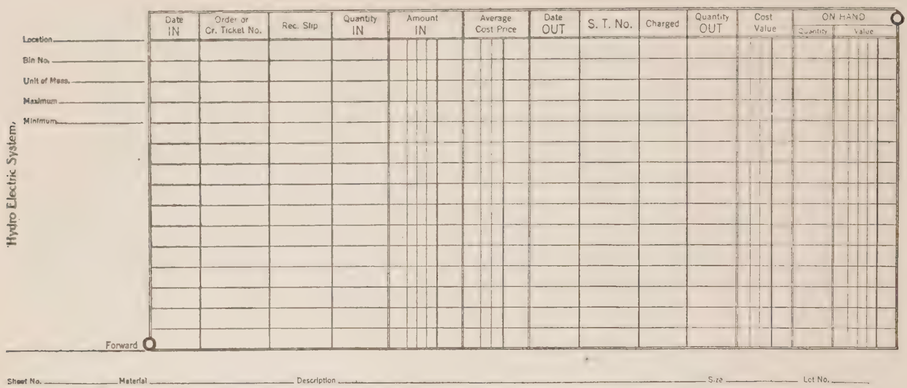


Fig. 10—Stock Ledger Sheet.

keeper. The Purchase Requisition follows and the serial number of this P.R. is noted by the Stock Ledger-keeper on his ledger sheet. This avoids duplication of Purchase Requisitions. The section foreman in spare time is checking the figures on his cards by physical count of his stock which is put into his bins in such a way that such a count is easy. The quantity on hand as shown on a Bin Card will not always agree with the quantity on hand as shown on the Stock Ledger sheet owing to the Requisitions going through which have not reached the Ledgerkeeper. The Bin Card thus gives more reliable information as to stock on hand and enables the Stores to operate on a lower inventory value.

The *Stock Ledgers*, however, show values as well as quantities and are used for pricing. As mentioned before, they are an Office record and kept as such in a safe place. Periodically there is an independent check and a report made to the Storekeeper as to the figures shown by the ledger—the Bin Cards and a physical count. Towards the end of the fiscal year this check is comprehensive and whatever adjustments necessary are made preparatory to the Inventory for the Accounting Department Annual Statement.

For Insurance purposes a check up on value of stock in Stores may be prepared monthly without interference with the regular work of the Stores staff.

Inventory.

On the last day of the fiscal year the Receiving Slips show the items to be included in that year's inventory. Those coming in at the beginning of the next year are stamped with the new year's figures—1930 or 1931—or as the case may be. This serves as a guide to the Accounting Department as to what invoices are to be charged in the current year. In writing up the stock an Inventory Slip is used in duplicate for each item. The office staff write the sheets in the Warehouse as the stock men call the description and stock numbers and quantities from the Bin Cards. The physical check with the Bin Cards has been made in the last few days of the year and all receipts and

issues have been carefully recorded. There is a rivalry between the section foremen as to their records. One sheet is left in each bin to show the stock has been written up. The other sheet goes into the Office where it is checked with the ledger and any differences accounted for and the slips are priced. Extensions are made on calculating machines and checked in same way. The inventory slips are serially numbered and all sheets issued must be accounted for. Sheets are then collated according to warehouse sections, and typewritten lists prepared for the Chief Accounting Officer and Engineering Department. The Engineers are thus in a position to study the stock for items becoming obsolete. I might state that the Engineering Department sends one or more of its staff to spot check the Inventory Slips after they are priced to verify in that way the accuracy of the inventory. While this work proceeds, all the year's Receiving Slips, Invoices, Requisition Supply Tickets, Delivery Slips, Transfers, Credit Tickets and Foremen's Credit Slips, etc., are being cleared up so that when the priced Inventory Slips have been extended and are being posted in the Stock Ledgers for the balances carried forward to start the new year, there is another chance to check for differences as to quantity and money value on each item. With an Inventory of three quarters of a million dollars and with an annual turnover of three million dollars, the variance with the Accounting Department Stores balances was one-fortieth of one per cent.

In the sketch herewith of the Stores routine you will understand there are many details not touched upon. Rather it has been the object to give only the main features of Stores operations which show how precautions are taken to insure the absolute accuracy of the information secured for the Accounting. There are three distinct divisions of the Stores work for which we seek to have accurate accounting—

Firstly—The receiving of all material and to know exactly what that material costs.

Secondly—The issuing of this material and charging it to the right accounts at the correct cost prices.

Thirdly—The Perpetual Inventory of material on hand and the correct cost value of that material.

If these three points are kept in mind and each transaction is carefully guarded against slipshod methods of handling, the Stores Accounting is a simple problem. The main thing is to keep records, not on scraps of paper or verbal reports depending upon memory—but on regular forms, be they few for a small Stores or a more elaborate system for large Stores. In small Stores, the Purchase Order and the Receiving Slip may be combined by sending into the Accounting Department a copy of the Purchase Order upon which has been noted by the Storekeeper the quantities received of each item on the Order. From this the Invoice can be checked and approved for payment.

A Requisition may be made out and filled and turned in by the Storekeeper if the organization is small and it can be priced in the Accounting Department. So may the Foreman's Credit

Slip be priced in the Office if the Stock Ledger is kept there. The Storekeeper may be held responsible for quantities only and his stock checked periodically by an independent checker. The Bin Card is an important Form in any Stores because it is kept with the material, and receipts and issues are entered as and when receipts and issues are made. Keep accurate records of material and accurate prices and bring them together somewhere and the Accounting will be accurate.

Association of Municipal Electrical Utilities

Auditors' Report

Statement of Receipts and Disbursements for year ending December 31st, 1931.

RECEIPTS

Cash in Bank, Dec. 31, 1930		$1,041.58
Membership fees:		
Utilities	$1,438.00	
Commercial	440.00	
		1,878.00
Convention Receipts		4,037.50
O.M.E.A. Contributions		447.30
City of Ottawa Contr'n		200.00
Interest on Bonds		77.50
Interest on Deposits		19.20
		$7,701.08

DISBURSEMENTS

Convention Expenses:		
Dinners and Luncheons	$3,870.50	
Entertainment	1,045.81	
Reporting	436.75	
Printing	360.45	
Badges	197.59	
Travelling Expenses	185.52	
Miscellaneous Expenses	101.38	
		$6,198.00
Carried forward		$6,198.90
Travelling Expenses		468.93
Remuneration, Secretary and Treasurer		275.00
Printing and Stationery		110.99
Bank Exchange		21.57
Postage		66.60
Balance		559.99
		$7,701.08

ASSETS

Balance at Bank		$ 559.99
Dominion, 1959, 4½% Bond, par value		500.00
Province, 1948, 5% Bond, par value		1,000.00
Projecting Machine	$243.45	
Less Am't written off	168.45	75.00
		$2,134.99

To the President of A.M.E.U.:

We have checked the above statement of Receipts and Disbursements with the books of the A.M.E.U., and it is, in our opinion, properly drawn up so as to represent the Cash transactions of the Association during the year, and the Assets disclose the true condition of affairs as at December 31st, 1931.

(Sgd.) W. G. PIERDON,
H. P. L. HILLMAN,
Auditors.

Report of Merchandising Committee

The Merchandising Committee held two meetings during the past year, one in May and one in November. At both of these meetings some very important matters in connection with Hydro Shop operation were taken up and discussed.

At each of the meetings the importance of having a prominent speaker address the Summer and Winter Conventions on some suitable merchandising subject was expressed and it was decided to secure if possible a speaker for the Summer Convention on Merchandising by the Public Utilities and for the Winter Convention if possible a paper on the Question of Bonusing Domestic Consumers' Services.

The following matters were brought to the attention of the meeting and after thorough discussion the recommendations submitted herewith were agreed upon:

1. Hydro Shop Surpluses

It is the unanimous opinion of the members of the Merchandising Committee that Hydro Shop surpluses should be restored to their original status enabling the Hydro Shops to receive the benefit through the interest charges against the Shop of accumulated surpluses from the time when reliable Hydro Shop records were installed.

2. Allowances for Wiring

The attention of the Committee was drawn to the fact that the Border Cities are making a special drive for range and water heater business by making special trade-in allowances on old ranges and water heaters and by bonusing the services of new range and water heater customers with an allowance of $15.00 toward the cost of range installation and $15.00 toward the cost of water heater installation or $30.00 if both are installed. The discussion on this matter resulted in a desire for more complete information on this practice with the result that a survey is being made among the various Power Companies in the United States and Canada where this practice is being inaugurated to secure full information on the subject.

3. Re Handling of Cheap Appliances

The question of whether or not Hydro Shops should engage in the merchandising of cheap electrical appliances including a cheap grade of lamps was thoroughly discussed and it is still the opinion of the Committee that Hydro Shops should merchandise only the highest quality of electrical goods.

4. Re Handling Assorted Lines of Merchandise

From the experience of members of the Committee in the handling of various makes of the different types of large appliances on the market, it was the consensus of opinion that Hydro Shops should keep their lines to as few makes of appliances as possible. One reason for reducing the number of lines and models of ranges, washing machines, vacuum cleaners and refrigerators particularly

is to keep the stock of these appliances to a minimum. Another reason is to facilitate the servicing of appliances sold and also to keep to a minimum the stock of repair parts which are necessary for servicing.

5. RE ADVERTISING

Once more the question of more extensive advertising by Hydro municipalities was brought up and discussed and it was agreed that Hydro municipalities in general should do more promotional advertising to keep before the consumers of electricity the advantages thereof and the economies of complete electrification of the home and otherwise. It was decided to approach the manufacturers of large electrical appliances to see if more promotional advertising could not be supplied by them for use by the Hydro Shops and others. It is felt that the manufacturers are not functioning to the fullest possible extent in promoting the sale of their own merchandise.

6. RE COMPENSATION FOR LOAD BUILDING

It was proposed that a recommendation be made whereby the Hydro Shops receive some pecuniary benefit for the increase in load effected by the sale of large current consuming devices. The opinion was expressed that if some compensation were given to the Hydro Shops by the Power and Light Departments of a Public Utility it could be arranged with the understanding that this compensation would be disbursed for extra and special advertising. After thoroughly discussing this matter, however, it was recommended that no such recommendations be made at the present time chiefly on account of the difficulty of arriving at a satisfactory uniform basis for calculating the compensation. It was felt, however, that if it were the intention to spend a sum of money received as compensation for load building in special advertising, since this compensation would have to be charged up in the books of the Utility as Promotion of Business Expense, the same results could be accomplished without the roundabout method of securing the funds by simply asking the Public Utility to do the advertising and spend the money direct. This emphasizes, however, the need for more promotional publicity.

7. RE SERVICING

A lively discussion took place on the matter of servicing electrical appliances and the methods in vogue in various municipalities. The principle of free servicing of electrical appliances was condemned; first of all, on account of the inconvenience and excessive cost of carrying in stock the parts for all makes of electrical appliances in use in a municipality where this practice is carried on, also on account of the abuses which dealers and others handling electrical appliances heap upon the Hydro Shop as well as on account of the abuses of customers who know that they will receive free service if anything goes wrong. The opinion was expressed that every Hydro municipality should have an inspector who would visit the consumers' premises periodically to check the appliances in use and also

to see whether or not any of them required repairs or service.

8. Re Hydro Lamps

The principles underlying the sale of Hydro lamps by Hydro Shops were discussed, and a recommendation was made that every Hydro Shop in the Province should push the sale of Hydro lamps as much as possible and should do more advertising both direct and indirect to insure the sale of more lamps.

9. Re Range Element Coils

The cost of replacement coils for range elements was the subject of considerable discussion and it was proposed that in order to reduce the cost of these coils some central depot be established to manufacture coils for all makes of ranges and supply them to the Hydro municipalities at cost. The difficulties in the way of such a procedure are numerous and other means of overcoming the excessive cost which now exists were recommended.

10. Re Metered Installment Sales

The inauguration of what is known as Meterice (a metering device attached to electric refrigerators as a slot machine for the payment of daily installments on the purchase of the refrigerator) by many American concerns has created an interest in this meter here and it was recommended that complete information on the use and cost of this device be obtained as soon as possible.

Minutes of Convention

The thirtieth Convention of the Association of Municipal Electrical Utilities was opened at the Royal York Hotel, Toronto, at 10.30 o'clock, on the morning of Wednesday, January 27th, 1932, with the President, Mr. J. W. Peart, in the chair.

It was moved by Mr. H. F. Shearer and seconded by Mr. A. S. L. Barnes:

"THAT the minutes of the last Convention and of the last meeting of the Executive Committee as published in the Bulletin be taken as read and adopted."—*Carried.*

The Secretary then read the report from the Auditors which showed a bank balance at the end of 1930 of $1,041.58 and at the end of 1931, $559.99. The assets of the Association, which included $1,500.00 in bonds, amounted to $2,134.99.

It was moved by Mr. E. V. Buchanan and seconded by Mr. R. H. Martindale:

"THAT the Auditors' report be received and adopted."—*Carried.*

Applications from the Hayes Products Limited, and R. M. Dewhurst for Commercial Membership were presented along with the names of Messrs. A. B. Hayman, R. H. Starr, H. J. Edwards and F. C. Adsett to become Associates.

It was moved by Mr. H. F. Shearer and seconded by Mr. O. H. Scott:

"THAT the applicants for Commercial membership be declared elected and the applications for Associates be accepted."—*Carried.*

Mr. O. H. Scott, Chairman, Merchandising Committee, presented a report from that Committee and

moved its adoption. On being seconded by Mr. G. J. Mickler, Mr. Scott's motion was carried.

Mr. E. V. Buchanan speaking on behalf of the special committee on research, reported progress.

A report from the Committee on Accident Prevention and Health Promotion was presented by Mr. R. S. Reynolds, Chairman, who moved its adoption. On being seconded by Mr. W. R. Catton, Mr. Reynolds, resolution was carried.

Mr. J. E. B. Phelps, Chairman, Rates Committee, advised that there was no report from that Committee.

The meeting was then given over to the discussion of subjects suggested by the delegates, which referred to the Meterice device, prepayment meters, distribution losses and the operation of the Pension and Insurance Scheme when an employee changes from one utility to another.

It was moved by Mr. W. R. Catton and seconded by Mr. E. V. Buchanan:

"THAT the question of prepayment meters be referred to the Rates Committee for investigation and report in all of its ramifications, the matter of rates, cost of meter, etc." —*Carried*.

The session then adjourned.

At 12.30 p.m. the delegates to the Convention were guests of the Electric Club of Toronto at a Luncheon. Mr. G. S. Stewart, President of the Electric Club was toastmaster and introduced Mr. Ellis Manning, Physicist in the Research Laboratory of the General Electric Company, Schenectady, N.Y., who gave an address entitled "Adventures in Science".

The afternoon session on this day was called to order at 2.30 o'clock with the President in the Chair.

The ballot for the election of officers for 1932 was declared closed and the ballot box given to Messrs. T. R. C. Flint and T. C. James, Scrutineers.

Mr. J. M. Prentiss, Stores Auditor, Toronto Hydro-Electric System, read a paper "Stores and Stores Accounting". Discussion following this paper was by Messrs. W. E. Wallace, O. H. Scott, J. Middlebrook, O. Thall, R. S. Reynolds, R. M. Bond, V. B. Coleman, R. H. Staford, J. E. Skidmore, G. A. Honsberger and P. B. Yates.

It was moved by Mr. J. E. Skidmore and seconded by Mr. P. B. Yates:

"THAT a hearty vote of thanks be extended to Mr. Prentiss for the paper presented by him."—*Carried*.

Mr. W. R. Catton, Manager, Hydro-Electric System, Brantford, read a paper entitled "Distribution System Problems". Discussion following this paper was by Messrs. V. A. McKillop, F. X. Brady, J. J. Heeg, P. B. Yates, E. V. Buchanan, C. E. Schwenger, Jos. Showalter, E. I. Sifton, H. D. Rothwell, H. S. N. Denef and C. E. Kirkby.

A hearty vote of thanks to Mr. Catton for his valuable paper was moved by Mr. E. V. Buchanan. On being seconded by Mr. O. H. Scott, Mr. Buchanan's resolution was carried.

The report of the scrutineers giving the result of the election of officers for the year 1932, was then read as follows:—

PRESIDENT — C. E. Schwenger, Toronto, Ont.

VICE-PRESIDENT—T. W. Brackinreid, Port Arthur, Ont.

SECRETARY—S. R. A. Clement, H.E.P.C. of Ontario, Toronto.

TREASURER—H. T. Macdonald, H.E.P.C. of Ontario, Toronto.

DIRECTORS—(from the membership at large)—E. V. Buchanan, London; R. L. Dobbin, Peterborough and O. H. Scott, Belleville.

DISTRICT DIRECTORS

NIAGARA DISTRICT:—W. R. Catton, Brantford, Ont.

CENTRAL DISTRICT:—J. E. Skidmore, Cobourg, Ont.

GEORGIAN BAY DISTRICT:—R. S. King, Midland, Ont.

EASTERN DISTRICT—M. W. Rogers Carleton Place, Ont.

NORTHERN DISTRICT:—C. J. Moors Fort William, Ont.

The session then adjourned.

At 7.00 p.m. the delegates of this Association met with those of the Ontario Municipal Electrical Association for the Convention Dinner. Mr. C. A. Maguire, President, O.M.E.A., as toastmaster, introduced Rabbi Eisendrath who gave an address entitled "The Human Family". There was also a short address by Mayor Stewart of Toronto, following which was a short variety entertainment.

The third convention session was called to order at 9.45 on the morning of Thursday, January 28th, when Mr. W. Ray Hunter, in charge of the Forestry Division, Operating Department, Hydro-Electric Power Commission of Ontario, read a paper entitled "The Truth about Trees" which was illustrated with lantern slides. Discussion following this paper was by Messrs. A. S. L. Barnes, A. M. Bowman, R. H. Martindale, E. V. Buchanan and C. E. Schwenger.

Mr. E. V. Buchanan moved a very hearty vote of thanks to Mr. Hunter for his paper which was very timely. On being seconded by Mr. C. E. Schwenger, the motion was carried.

The meeting then became a joint session with the Ontario Municipal Electrical Association with Mr. C. A. Maguire, President, O.M.E.A., as Chairman. Honourable George Challies, B. Ph., Provincial Secretary and Registrar, gave an address on "The St. Lawrence and Its Development."

It was moved by Mr. Fred Biette:

"THAT a hearty vote of appreciation be expressed to Mr. Challies and that, if possible, his address be printed in pamphlet form and sent to the municipalities. On being regularly seconded, Mr. Biette's motion was carried.

Mr. T. J. Hannigan read a report showing the operation of the Pension and Insurance Scheme for municipal utility employees.

A letter inviting the two Associations to hold their Summer Convention at Bigwin Inn was read. This showed the dates of June 23rd, 24th and 25th to be available. It was also suggested that Windsor be considered as a place of meeting for the Summer Convention. The Chairman asked for a show of hands on the two proposals which gave a majority in favor of Bigwin Inn. It was therefore decided that the Summer Convention would be held at Bigwin Inn on the dates suggested.

The session then adjourned.

At 12.30 o'clock the two Associations met for the second convention luncheon with Mr. J. W. Peart, President, A.M.E.U., as toastmaster. Mr. E. V. Buchanan introduced Rev. John Inkster, D.D., who gave an address on Palestine. There was also a short address by Right Honourable Arthur Meighen, Commissioner, Hydro-Electric Power Commission of Ontario.

The fourth session of the Convention opened at 2.30 p.m., with the President, Mr. J. W. Peart, in the chair.

Mr. H. E. Guilfoyle, F.C.A., of Clarkson, Gordon, Dilworth, Guilfoyle and Nash, Chartered Accountants, Toronto, gave a paper entitled "Reserves and Fixed Charges". Discussion following this paper was by Messrs. Geo. Appleton, E. I. Sifton, J. H. McTavish, E. M. Ashworth and O. H. Scott.

It was moved by Mr. E. M. Ashworth and seconded by Mr. O. H. Scott;

"THAT the Association tender a hearty vote of thanks to Mr. Guilfoyle for his paper."—*Carried.*

The next item on the program was a paper on "Ground Connections for Distribution Systems" by Mr. A. G. Lang, Distribution Engineer, Electrical Engineering Department, Hydro-Electric Power Commission of Ontario. Discussion following this paper was by Messrs. Wills Maclachlan, F. X. Brady, R. H. Martindale, A. S. L. Barnes, C. E. Kirkby, H. Bonis, P. T. Gaston, A. E. Rumball, R. J. Smith and C. T. Barnes.

It was moved by Mr. R. J. Smith and seconded by Mr. C. T. Barnes;

"THAT a hearty vote of thanks be extended to Mr. Lang for his timely and interesting paper on grounding. —*Carried.*

Before retiring the President, Mr. J. W. Peart, gave a short address congratulating the newly-elected officers and assuring the Association of its management being in good hands for 1932.

The Convention was then closed.

On Friday, January 29th, the delegates were the guests of the Hydro-Electric Power Commission of Ontario and the Toronto Hydro-Electric System, on inspection tours, visiting the laboratories, terminal and distributing stations in Toronto.

The register shows the number of delegates at the Convention to have been 473, classified as follows:—

Class A	114
Class B	171
Commercial	88
Associates	68
Visitors	32

There were 595 present at the Convention luncheon on the first day, and 454 at that of the second day. At the Convention dinner, 468 attended. 101 delegates were entertained on the inspection tours of Friday morning.

Minutes of Executive Committee Meeting

A meeting of the 1932 Executive Committee was held at the Royal York Hotel, Toronto, on the evening of Wednesday, January 27, 1932. The meeting was called to order at 10.00 p.m. by C. E. Schwenger, newly elected President. Other Executive Committee members present were—

Messrs. H. T. Macdonald, W. M. Rogers, J. E. Skidmore, T. W. Brackinreid, T. J. Hannigan, J. W. Peart, O. H. Scott, C. J. Moors, R. S. King, W. R. Catton and S. R. A. Clement.

Mr. S. Forsythe, Assistant Manager, Bigwin Inn, was introduced, who addressed the Committee relative to holding the Summer Convention there. It was moved by Mr. J. W. Peart and seconded by Mr. T. W. Brackinreid:—THAT Mr. Forsythe put in writing the proposition and concessions outlined by him and that it be held over till the next day for decision.—*Carried.*

A letter from Mr. T. J. Hannigan, Secretary, O.M.E.A., that had been read during the Convention session and referred to this Committee, suggesting changing the Association's by-laws respecting the membership of Commissioners in it, was discussed. It was decided that no action be taken on this matter at this time.

A letter from Mr. D. J. McAuley, Secretary of the Committee on Accounting and Office Administration, attaching proposed amendment to the by-laws of the A.M.E.U. was read. The proposed amendment suggested the formation of divisions in the Association as follows:—

(1) Divisions of the Association consisting of Engineer, Accountants, or other classes of persons included in the membership of the Association may be established by the Board of Directors, on the request of twenty members. Any member of the Association may register in any Division of the Association in which he is interested.

(2) Such Divisions shall elect their own officers and committees, and make rules for their government not inconsistent with the By-laws of the Association, but these rules must first be approved by the Board of Directors.

(3) The Presiding Officer of each Division shall, ex-officio, be a member of the Board of Directors of the Association, and a representative of each division shall be on each standing committee where representation is necessary.

(4) The Board of Directors of the Association shall determine from time to time the amount the Division shall receive towards its expenses.

Action on this proposal was left over to the next meeting of the executive committee.

Committees for the year 1932 were then drafted as follows:—

Papers Committee:—E. V. Buchanan, London, Chairman; T. R. C. Flint, Toronto; M. B. Hastings, Powerlite Devices, Limited, Toronto; E. R. Lawler and W. P. Dobson, H.E.P.C. of Ontario, Toronto.

Convention Committee:—T. W. Brackinreid, Port Arthur, Chairman; D. B. McColl, Walkerville; V. A. McKillop, London; F. Mahoney, Canadian General Electric Co., Toronto; H. T. Gibbs, Canadian Westinghouse Co., Toronto; C. H. Hopper, Ferranti Electric, Toronto; R. H. Starr, G. F. Drewry and J. W. Purcell, H.E.P.C. of Ontario, Toronto.

Regulations and Standards Committee:—J. W. Peart, St. Thomas, Chairman; R. J. Smith, Perth; W. J. Jackson, London; P. B. Yates, St. Catharines; E. I. Sifton, Hamilton; F. W. Peasnell, Toronto; W. P.

Dobson, H.E.P.C. of Ontario and A. G. Hall, Electrical Inspection Dept., Toronto.

Committee on Accident Prevention and Health Promotion:—J. E. Skidmore, Cobourg, Chairman; R. S. Reynolds, Chatham; F. D. Hubbell, Windsor; H. G. Hall, Ingersoll; E. J. Stapleton, Collingwood; V. A. McKillop, London; C. E. Schwenger, Toronto; J. W. Peart, St. Thomas; C. A. Walters, Napanee; T. C. James, G. F. Drewry, E. R. Lawler and Wills Maclachlan, H.E.P.C. of Ontario, Toronto.

Merchandising Committee:—O. H. Scott, Belleville, Chairman; J. E. B. Phelps, Sarnia; F. S. Rhodes, Windsor; W. H. Childs, Hamilton; I. N. Pritchard, Chatham; H. F. Shearer, Welland; A. W. J. Stewart, Toronto and G. J. Mickler, H.E.P.C. of Ontario, Toronto.

Rates Committee:—W. R. Catton, Brantford, Chairman; P. B. Yates, St. Catharines; E. I. Sifton, Hamilton; O. M. Perry, Windsor; R. S. Reynolds, Chatham; V. S. McIntyre, Kitchener, and all of the members of the 1932 Executive Committee.

Committee on Accounting and Office Administration : — R. L. Dobbin, Peterborough, Chairman; D. B. McColl, Walkerville; W. H. Childs, Hamilton; A. B. Manson, Stratford; I. N. Pritchard, Chatham; W. E. Wallace, Windsor; R. S. King, Midland; H. Clegg, Peterborough; A. L. Farquharson, Brockville; Geo. Appleton, Toronto; G. F. Drewry and R. M. Bond, H.E.P.C. of Ontario, Toronto.

Auditors : — W. G. Pierdon, H.E.P.C. of Ontario, Toronto and H.P.L. Hillman, Toronto.

It was moved by Mr. O. H. Scott and seconded by Mr. W. M. Rogers:

"THAT the Committees as drafted be declared appointed."—*Carried.*

It was moved by Mr. O. H. Scott and seconded by Mr. T. W. Brackinreid:

"THAT the Secretary and Treasurer be paid gratuities of the same amounts as given them last year." —*Carried.*

Mr. H. T. Macdonald spoke in reference to the expenses of operating the Association, pointing to the need of retrenchment concerning some items. It was moved by Mr. O. H. Scott and seconded by Mr. R. S. King:

"THAT the President, Secretary and Treasurer be a committee to budget expenses for the coming year." —*Carried.*

There being no further business, the meeting then adjourned.

Further Convention Proceedings will appear in the March Number

THE BULLETIN

Published by

HYDRO-ELECTRIC POWER COMMISSION

of Ontario

190 University Ave.
Toronto

Subscription Price $2.00
Per Year

Adventures in Science

By Ellis Manning, Physicist, Research Laboratory, General Electric Company, Schenectady, N.Y.

(Address to the Electric Club of Toronto, Ontario Municipal Electrical Association and Association of Municipal Electrical Utilities at Toronto, January 27, 1932.)

THE job of doing research is not always an easy one. It is, however, much more fun to do research than it is to talk about it.

On the whole, very few people really understand what research is. Perhaps I can make my point clear in this way: A youngster was asked to write an essay on Benjamin Franklin and he wrote as follows: "Franklin was born in Boston. Sometime later he moved to Philadelphia. One day as he was walking along the street eating a hot dog, a very good looking girl sitting on a door-step laughed at him. Later he married the girl,—and discovered electricity." Many people, I think, believe that electrical research is accomplished in somewhat that manner.

The popular use of the term 'magic' in connection with research laboratories is a very gross misuse of the term. Those who know of the long-time investigation, the persistent experiment, the oft repeated failure to obtain the thing sought, will know that any word which conotes accomplishment with a wave of the hand should not be used to describe any sort of research.

Again, members of research staffs are often described as engineers. There are, in fact, very few engineers on the staff of the laboratory in Schenectady. The mental attitude and aptitude of the research worker differs widely from that of the engineer. The engineer is in somewhat the same situation as the medical doctor. Neither can afford to make mistakes. In that comparison, I suppose the medical doctor has the advantage; he can usually bury his. But the engineer who makes a fundamental mistake is sure to cause his company loss of money, and is quite apt to lose his job.

On the other hand, the research

CONTENTS

Vol. XIX No. 3

March, 1932

man is usually on new ground. Often he does not know exactly where he is going, or precisely how he is going to get there. Thus he makes mistakes very frequently. He is fortunate, indeed, if he does not make the same mistake too often.

Generally speaking, the research laboratory attacks two different kinds of problems. One sort of problem deals with the acquisition of certain information definitely needed in engineering practice. This sort of work is sometimes described as the solution of practical problems. In addition to these, there are under investigation, many problems instigated by the curiosity of individual members of the staff, and carried on primarily for the purpose of satisfying that curiosity. It has been found, time after time, that practical or commercial results may come from this second type of problem quite as frequently as from the first. In the case of the practical problem; the investigation takes a definite direction and is, therefore, apt to be sharply limited in scope. In the case of the problem pursued to satisfy someone's curiosity, attractive byways may prove as interesting as the main investigation, and often times prove to be of considerable importance.

Let me illustrate by citing the case of a practical problem, which developed unexpected results. Some months ago, there was a need for high power, very high frequency oscillators,—that is, for vacuum tubes which could create space disturbances of very short wave lengths, and which would have a large power output. The vacuum tubes which were then available could be made to produce satisfactory power outputs at normal broadcast frequencies, but these same tubes, made to oscillate at much higher frequencies, gave very limited power outputs.

The Laboratory studied this problem for some time, and finally produced vacuum tube oscillators that gave a satisfactory output at the desired frequencies. As the work was nearing successful completion, an unusual observation was made. The men working in the neighborhood of the experimental equipment began to feel queer. They came to work in the morning feeling quite fit but several hours afterwards, they did not feel at all the same.

Our medical man, upon investigating, found that they were running temperatures above normal. At about the same time word came to us that artificial fevers induced by inoculating a patient with malaria, or with certain types of proteins, were being used more or less effectively in combating some types of infectious disease. Since the disturbed space in the neighborhood of these oscillators produced what might be called an artificial fever, Dr. Whitney and his associates felt that

it might be worth while experimenting with such apparatus in this direction.

Arrangements were made with the Ellis Hospital in Schenectady and with the Albany Medical School, and experiments were carried out with various animals,—rats, rabbits and dogs. These experiments proved to be so successful that a number of pieces of such apparatus were constructed and loaned to as many medical research institutions, for human experimentation.

We would much prefer to have the medical doctors do the talking about the effectiveness of this kind of treatment. At the moment, several of the men who have been using this apparatus are about to publish their first experimental results. Dr. Hinsie, of the Columbia Medical Centre, Dr. Tenney, of the Fifth Avenue Hospital, also in New York, and Dr. Carpenter, of Rochester, N.Y., all have indicated striking success in their experiments, with this type of radiation. It seems to be a useful method in combating certain types of blood diseases, and may prove a valuable tool in handling bone and joint diseases. Dr. Whitney describes the effect of the radiation by saying that it is equivalent to heating a barrel of beer inside a bale of hay without heating the hay. In other words, the blood stream is heated without materially heating the flesh and tissues.

It looks as though that particular investigation — accidental if you please to call it that—may put in the hands of the medical profession, a new and useful tool. Thus, practical problems sometimes will uncover byways that are as interesting and as important as the original problem itself.

Most of you know that Coolidge has for many years been 'playing' with high speed electrons thrown outside of the generating tube. These streams of electrons are called cathode rays. Recently he has been interested in trying to make tubes that would operate at very high potentials. With 350,000 volts applied to such a tube, the electrons thrown into the air move at speeds in excess of 100,000 miles per second. With higher potentials applied to the tube, the speed of these electron bullets can be increased to over 150,000 miles per second. No one knows exactly what such streams of electrons can be made to do. 'Playing' with such electron streams, as Coolidge is doing, is lots of fun and may, in time, develop some very practical uses.

Medical men are now using radium and other radio active substances with some success. The beta rays from radium are simply streams of electron bullets, identical with Coolidge cathode rays, except that the beta rays move with higher velocities. By applying potentials of 3,000,000 volts to cathode ray tubes, the electron stream from such tubes would have approximately the same speed as the beta rays from radium.

The radiations from these radio active substances come at random, both in time and space. No one has yet learned to control them; hence they must be used as Nature provides them. The electron stream from a cathode ray tube can be readily controlled. If its output can be made to do the same jobs that the beta rays are now doing, it would provide a

more flexible and perhaps a more useful source than the radio-active compounds. Incidentally, the number of electrons shot out from one such tube corresponds roughly with the beta radiation from a ton of radium. As you may know, there is available for use, in all the world, somewhat less than a pound of radium.

The high speed bullets from radio active substances are being used to-day to smash atoms of matter, and in that way, to provide us with more information than we now possess, concerning these fundamental building bricks of the universe. As the voltage applied to the cathode ray tubes is increased, it is thought that these streams of electrical bullets can be effectively used in this way.

A cathode ray tube and an X-ray tube are first cousins, one to the other. In the x-ray tube, the stream of swiftly moving electrons is stopped by a metal target placed inside the glass envelope. Some of the energy of the electron is converted into a space disturbance of extremely short wave length, called an x-ray. The penetrating power of the x-ray depends upon the voltage applied to the tube,—the higher the potential, the more penetrating the x-ray. Along with his work on cathode rays, Coolidge is learning to produce million volt x-rays. With such short wave length radiation, it is possible to take pictures through 4 inches of steel. It is becoming common practice at Schenectady to use high voltage x-rays in the routine inspection of castings and other fabricated products. Such a procedure enables the manufacturer to discover flaws in opaque material that could not otherwise be detected.

Please do not suppose that most of the work of the Laboratory is in some way connected with vacuum tubes, simply because the things so far discussed have dealt with this type of investigation. One of the younger men in the Mechanics Section of the Research Laboratory, has recently produced a gadget that may prove to be of real commercial importance. This man came to the laboratory some three years ago, from a teaching position. He was most curious about critical speeds and has spent most of his time studying them. A short time ago, his studies led to the development of a machine for production balancing of rotating parts. The business of balancing rotating machinery is not only a serious one, but one which is very difficult to achieve. The situation is similar to that of the farmer with a leaky roof. In good weather it is unnecessary to repair the leak, and in very bad weather, it is very difficult. Rotating machinery, at rest, does not vibrate, and when it is in motion, it is mighty awkward to get at.

Many mechanical men will recognize the fact that when unbalanced rotating machinery is in motion, the heavy side runs out,—that is, farthest from the centre of rotation. If the rotating part is operated above its critical speed, a 180° phase shift occurs. I mean by that, the light side of the rotor is then farthest from the centre of rotation. Applying this fact, Thearle designed a balancing machine which will automatically, and most accurately, correct the unbalance and tell the operator

exactly how much weight to add and precisely where to add it, to produce a perfectly balanced machine. It appears, again, that a more or less academic study will result in the commercial production of rotating machinery quite free from vibration due to unbalance.

I believe that some of Langmuir's work can be used to emphasize this point. Many years ago, Langmuir became very curious about the size and shape of these small things we call molecules. It is not an easy matter to determine physical dimensions of molecules, and yet, by persistent study, Langmuir succeeded in getting the information he sought. Fairly recently, in the Chemical Section of the Laboratory, some of the men have succeeded in obtaining what appears to be a flexible molecule.

The plastic materials which we now have are compounds that are externally plasticized. In many respects these compounds resemble molasses taffy. Taffy, when properly 'worked', is plastic. The plastic taffy becomes brittle after a time. In the same way, time and temperature conditions will modify the physical characteristics of most of our plastics. Kienle, and some of his associates, by producing flexible molecules, have succeeded in making plastics that will not age and which are independent of temperature changes, provided the temperature does not reach the point at which the molecule itself dissociates.

Vacuum tubes are so flexible, and can be made to do such a variety of jobs, that it is not surprising to find them entering the field of delicate measuring instruments. The newest vacuum tube that has come from the Research Laboratory is one which will take the place of galvonometers and electrometers.

Measurement is, of course, a fundamental yardstick by which information is obtained. Until you measure, you possess only qualitative information. It is through measurement, and fairly accurate measurement, that we get dependable and useable information. Galvonometers and electrometers have given us accurate information, but those of you who have used either instrument know that such use entails many difficulties. Once such an instrument is set up and properly adjusted, it is customary to bring to it the thing to be measured. This new vacuum-tube substitute will provide a rugged portable method for obtaining accurate information concerning extremely small amounts of electrical energy.

The new vacuum tube can detect the presence of 10^{-17} amperes. That fraction, in the more usual nomenclature, would be expressed as one hundredth of a millionth of a billionth of an ampere. Such fractions are meaningless. Perhaps I can visualize it for you in this way: The current flow through a 50 watt lamp is roughly half an ampere. If that half ampere be compared with the total flow of water over Niagara Falls, per year, then 10^{-17} amperes would compare with half an ampere as a trickle of two drops of water per year compares with the total flow over Niagara. Such a tube is, we think, going to be a most valuable tool in adding to our knowledge of electricity and what it can be made to do.

At the moment, one of the most interesting games which is being played in the laboratory is the game of 'numbers'. Such a game occupies the attention of your own Dr. Dushman, and a group of people with the same training and interests. Everyone knows that he may sit down to a radio set and, by turning its dial, obtain a variety of responses. One number on that dial may bring dance music; a different number may bring an informational talk; a still different number may bring concert music. Each number has a message of its own.

Radio broadcast numbers, or wave lengths, are usually given in meters. Actually, of course, the unit in which the wave length is measured is not particularly significant. If I may be permitted to choose my own unit of wave length, then there will be an unbroken series of numbers beginning with 1 and running to infinity. Of this vast spectrum of numbers, we have at present obtained messages from just a few of the total. Certain of the lower numbers,—the ones that are popularly called cosmic rays,—appear to be bringing us messages of the synthesis of matter from energy. Such, at least, is the opinion of one distinguished physicist. That opinion may be right or it may be wrong. Certainly those numbers contain messages which, when properly understood, will prove important.

Some of the higher numbers are what we call gamma rays. These numbers tell us of the disintegration of matter, and of its change, partly at least, into energy. Still higher numbers are called x-rays, and the messages they bring to the medical profession and to industry in general, are well-known. A few of the higher numbers,—those that fall in part of the ultra-violet spectrum,—appear to be telling us something of the mechanism by which the blood utilizes calcium and perhaps some other chemical elements.

These represent merely a beginning in the process of unlocking the messages contained in such numbers. A great many people in the laboratory feel that as more and more of these messages are interpreted, information as valuable, or perhaps more valuable, than that which we have already received will become available.

For more than ten years, the Laboratory has been trying to extend the usefulness of vacuum tubes so that they may be helpful in doing engineering jobs. The high vacuum tube is amazingly versatile, but the amount of energy which can be controlled through the tube is relatively small,—too small to be of real interest to many members of the engineering profession. The Laboratory has been trying to find ways of making vacuum tubes that will control large amounts of energy, and we are beginning to meet with some success. Laboratory tubes, of the type called thyratrons, have been built which will control hundreds, and even thousands, of amperes.

As yet, most of these tubes are strictly Laboratory products, and are not available commercially. In the Laboratory, however, tubes of this sort have been used to run alternating current motors from direct current sources, and direct current motors from alternating sources, both with flexible speed control from zero to

maximum. Such tubes used in pairs will serve to convert direct current into alternating current,—a job which can now be done only by some form of rotating machinery.

One of your Toronto men is now at work attempting to learn how tubes of this sort, with a low-pressure gas content, can be made to operate at extremely high voltages. We do not know when, or if, it will be possible, by using tubes of this sort, to send high voltage direct current across your transmission lines. If it can be done, it would have certain advantages. Longer lines could be constructed; much of the inconvenience that is inherent in alternating current transmission, and some of the losses that characterize such transmission, would be eliminated. You would have control of the direction of flow of energy over your lines,—something which you do not now have,—since all vacuum tubes are merely one-way traffic highways for electrons. There would be no need to change existing systems,—but it looks as though the present transmission lines could in that way be used to carry very much larger amounts of energy.

A short talk of this sort cannot give an adequate conception of the work of the laboratory. May I not extend to you, individually, an invitation to visit the Research Laboratory whenever you are near Schenectady. You will find there an atmosphere very similar to that in the Graduate Schools of any University. The people are ready and willing to talk with you and you will find there a very cordial welcome.

Every one likes to feel that his job is important. While it is true that many people on the Laboratory staff are not working on definite practical problems, it is also true that most of the engineering progress that is made is merely the practical application of scientific facts. Engineering progress during the last twenty years has been rapid, and has resulted from the application of scientific information accumulated over a long period of years. If that progress is to be continued there must be some group or organization whose purpose it is to seek out and make available additional stores of fundamental information. In the Laboratory, we like to feel that our job consists in supplying new facts, and in so doing, provide the raw material upon which future engineering progress will be based.

Window Display, Forest Public Utilities Commission.

Reserves and Fixed Charges

By H. E. Guilfoyle, F.C.A., Clarkson, Gordon, Dilworth, Guilfoyle and Nash, Chartered Accountants, Toronto

(Paper read before Association of Municipal Electrical Utilities at Toronto, January 28, 1932)

THIS Paper is prepared with a knowledge of the fact that it is intended to be read before an audience of men who are directly interested in the administration of Municipal Hydro-Electric Utilities and is not expected to fit, in every particular, the requirements of other Utilities in Ontario or even privately owned Electric Utilities elsewhere. The reason for this is apparent if reference is made to the provisions of the Power Commission Act and to regulations set by the Hydro-Electric Power Commission in order that the accounting and, to some extent, the administration of the Municipal Electric Utilities may be standardized throughout Ontario.

Depreciation Reserves

It is immaterial whether you call these Reserves for Depreciation or Reserves for Renewals. For all practical purposes these two titles have the same meaning and the Reserves we have in mind are those that will take care of the loss sustained when each unit of plant has run its life of service, requires to be displaced and the original cost (less the salvage value) has to be written off.

The term "Reserves" indicating plurality is intentionally used in order that a distinction may be drawn as between the reserve set up against—

(a) General Plant

and the separate reserves that should properly be set up against

(b) Utility Equipment, including Automobiles and Trucks

(c) Office Equipment

(d) Miscellaneous Equipment

The rates of depreciation on the last mentioned three classes of equipment are almost invariably higher than the rate on the general plant and the turnover in certain of such equipment, —especially automobiles and trucks— is greater than in the general plant.

The term "Depreciation Reserve" is commonly used although as a matter of fact it is a Reserve against Depreciation and Obsolescence. I am assured by the Engineers of the Hydro-Electric Power Commission who made calculation of the depreciation rates presently in use by your Electric Utilities, that such rates (along with the interest additions on the credit balances in Reserve Accounts) are adequate to provide against depreciation caused by wear and tear and also against obsolescence.

The computations made by the Engineers of the Hydro-Electric Power Commission when arriving at the rate of depreciation to be employed by any Municipal Electric Utility (or any group of them similar as to size and other conditions) indicate that the Engineers had regard to—

1. The several classes of Plant, including buildings, lines, equipment, etc., and also the non-depreciable assets.
2. The capital invested in each of such classes.
3. The estimated life of service of each class.
4. The estimated residual value of each class.
5. The portion of the investment in each class to be written off over the life of service.
6. The annual instalment necessary to take care of such write-off on each class of plant.
7. The aggregate of the annual instalments of all classes and the percentage or relation of such aggregate to the total investment in plant.

To the last mentioned percentage is added a more or less arbitrary rate, based on experience, to cover obsolescence, and the total percentage thus arrived at is the one communicated to the Municipal Electric Utility (or to each of a group similar as to size and other conditions)for use by it in the computation of its Reserve against Depreciation and Obsolescence.

There are different bases upon which depreciation rates may be calculated but only two in which we are presently interested, namely—

1. A straight line basis
2. A sinking fund basis

The straight line basis is very simple, for example—on a plant (or class of plant) having an estimated life of twenty years a rate of 5per cent. is employed and calculated on the investment in such plant, less the estimated residual value. Where the sinking fund basis is used a lesser rate than the straight line rate is originally struck but the reserve created by such rate must be improved from year to year by the addition of interest on the credit balances in the Reserve Account. Such additions are usually referred to as "Interest Improvement" and the rate of interest must of necessity be conservative and constant.

Regardless of the fact that Industrial Corporations employ almost invariably a straight line rate of depreciation in building up their depreciation reserves, the use by the Municipal Hydro-Electric Utilities of a rate (or rates) computed on the sinking fund basis is proper and not open to question. Ultimately the Depreciation Reserve of any Utility will reach the same aggregate as it would if it were calculated on a straight line basis. There is one precaution, however, that requires to be taken, although the necessity for such precaution may seldom arise,—Where a substantial item or unit of equipment requires to be dismantled and scrapped within a few years of its installation and long before the average life estimated for such equipment, the loss thereon cannot all be charged against the depreciation reserve as the reserve would be found to contain only a comparatively small provision in respect of the particular unit of equipment dismantled. Such a case must be regarded as of the nature of a contingency, and there should be charged against the Depreciation Reserve only such an amount as is found by calculation to be contained in the Reserve in respect of that particular equipment. Were the whole amount of the loss charged

against the Depreciation Reserve such reserve would be deprived of a substantial amount that would otherwise remain therein and be increased by the interest improvement.

It is to be expected that all or nearly all of the Municipal Hydro Electric Utilities throughout Ontario have reached the age when charges against the Depreciation Reserve are found necessary because of the displacement of old units of plant and the installation of new units to replace them. In this connection it should be emphasized that it is the original cost of the units of plant displaced that is chargeable against the Depreciation Reserve and not the expenditures made on the installation of the new units. The reasons for this are many and are sufficient; some of them might be mentioned—

1. The reserve (against which the charge is to be made) has been built up by a rate computed on the original cost.
2. The new units installed to replace the old may be of an entirely different capacity and character.
3. The original cost of the units displaced may not be equal or nearly equal to the cost of the new units installed.
4. The book value of the plant of a Utility (apart from the Depreciation Reserve) should at all times be the aggregate of an inventory of the existing plant valued at the cost thereof regardless of when the units comprised in such plant were installed.

RESERVE AGAINST CONTINGENCIES

There is no provision contained in the Depreciation Reserve for charges other than those occasioned by depreciation and obsolescence. Contingencies met with such as damages to lines and equipment caused by sleet storms, burnt-out transformers, etc., should not be charged against the depreciation reserve as the result would be to impair such reserve and leave it inadequate for the purposes for which it was set up. Neither is there any provision in the Depreciation Reserve for Extraordinary Maintenance.

Upon inquiry I learn that your Municipal Electric Utilities do from time to time meet with contingencies of the nature above described and do occasionally have to make expenditures on maintenance of an extraordinary character. There is therefore established the necessity for a Contingency Reserve. Some of the Municipal Electric Utilities are in all probability meeting with other contingencies or extraordinary expenditures, such as the premature dismantling or removal of pole lines, and some of the expenditures incurred cannot properly be charged against the Depreciation Reserve.

The creation of a Contingency Reserve has the effect of spreading over several years of operations, the contingency and extraordinary charges met with, and results in stabilizing the operating and maintenance expenses. It is not suggested, however, that there should be a transfer at any time of a lump sum out of Ordinary Maintenance Account against the Contingency Reserve but rather that the exact expenditures

required to be made to cover maintenance extraordinary should be charged directly against the Contingency Reserve.

If in any Municipal Electric Utility a Contingency Reserve has not already been created such a reserve might well be started by a round-sum transfer from Surplus Account and thereafter built up at a rate to be established. The Engineers of the Hydro-Electric Power Commission and of the Local Electric Utilities can in all probability introduce important factors in the establishment of a rate for setting up a Contingency Reserve, but one factor of importance would be the experience of the Local Electric Utilities taken in classes (according to their sizes and conditions) but not taken individually. In striking a rate upon which to build up a Contingency Reserve a liberal attitude should be adopted so that the reserve may be adequate to take care of perhaps greater and more numerous contingencies that may be met with as the plants grow older.

Debentures Retired Reserves Sinking Fund Reserves

The retirement out of revenue of the amounts necessary to be paid yearly to meet—

(a) Serial Debentures and/or

(b) Sinking Fund payments for the retirement ultimately of term debentures.

automatically creates reserves which represent the equity of the Municipality (or the consumers) in the Utility.

Mention is sometimes made of the fact that in Municipal Hydro-Electric Utilities provisions are made out of revenue for both—

(a) Depreciation and Obsolescence of the Plant, and

(b) The retirement of Debenture Liabilities.

The practice would seem to be both justifiable and sound for the following reasons—

(1) There is no relation between the life of the debentures and the lives of the individual classes of plant against which provision for depreciation is being made.

(2) Provisions against depreciation and obsolescence in a plant is essentially an operating charge and is little different to ordinary maintenance except that the provision is spread evenly over a period of years and expended at future dates.

(3) The depreciation reserve is created with a view to perpetuating the Utility—in order to do this provision must be made for the renewal of each class of plant as it wears out or becomes obsolete. The lives of the different classes of plant vary considerably.

(4) Provisions for depreciation is not made against non-depreciable or intangible assets.

(5) On the other hand the debenture borrowings for investment in non-depreciable and intangible assets (as well as those for investment in depreciable assets) must be repaid.

(6) Debenture Retirement and Sinking Fund Reserves are being created only in respect of debenture borrowings, the proceeds of which have been invested in plant, and not in respect of the depreciation and other reserve funds which have also been invested in plant.

(7) It is a sound and conservative policy to create out of revenue adequate and substantial reserves. If in any instances sufficient revenue is not available for the purposes of both reserves above mentioned and *some reduction in the charges is found essential to be made*, it would seem desirable that a longer period of retirement of the debenture debt be adopted, thereby reducing the yearly charge, rather than that the depreciation reserve should be tampered with.

The suggestion is sometimes made that we are paying for and passing on a legacy to the next generation. In these times of many changes who knows what will occur in the next generation or what kind of a legacy we are handing on to them.

Reserve against Public Liability

Upon making inquiry it is found that by far the majority of the Municipal Hydro-Electric Utilities insure against public liability under the Group Plan arranged for by the Hydro-Electric Power Commission, and by that Commission placed with outside Companies. Certain other Utilities place their public liability insurance directly with outside Insurance Companies, while a limited number of them are setting up their own reserves against public liability risks. To those setting up their own reserves the suggestion is made that they create such reserves at the same rates and on the same bases as are charged by outside Insurance Companies. To adopt rates lower than those employed by outside Insurance Companies would be running a risk that might well be avoided. It is also suggested that none but the larger Utilities should attempt to carry their own reserves against Public Liability as they only have sufficient spread to carry the risk of individual losses of perhaps major amount.

Reserve for Workmen's Compensation

Upon inquiry it is learned that with very few exceptions the risk of accidents to employees of the Municipal Hydro-Electric Utilities is being carried by the Workmen's Compensation Board and the assessments or premiums paid thereto. To the few Utilities who are building up their own Reserves to take care of the risk of accidents to employees it is suggested—

1. That in setting up such reserves they employ the rates used by, and revised from time to time by, the Workmen's Compensation Board and which are available in the form of a printed booklet issued by the Board.
2. That at the end of each fiscal year they compute the capitalized value of the pensions payable, on the same basis as that employed by the Board.
3. To the capitalized value of the pensions payable should be added any claims that are not in the form of pensions and the aggregate should then be compared with their Reserve to see that such Reserve is adequate to cover the gross of the liabilities above described.

Reserve against Improvements in Leasehold Premises

Where leasehold premises are occupied and improvements or alterations

have been made therein to serve the purposes of a Local Utility, the cost of such improvements and alterations, less any recoverable residual value, should be amortized and written off against revenue within the period mentioned in the lease. If no lease exists a reasonable period over which to spread the charge might be five years—unless occupancy for a shorter period is expected. Having in mind the necessary covering of fire insurance it would seem advisable that a reserve be created rather than follow the practice of writing down the investment in the Improvements and Alterations.

Reserve against Stores Inventories

When inventories are taken from time to time of the construction and maintenance materials and supplies it is the rule rather than the exception that some obsolete or damaged materials or parts are found. In order that such inventories may be carried at their true value on any financial statement of a Local Utility provision must be made against the obsolete or damaged materials and parts. This can be done by a write-down of the inventory or the creation of a reserve there against. The measure of the amount of such write-down or such reserve rests entirely with the officers or employees of the Utility familiar with the inventory and its true value.

Reserve against Accounts Receivable

It would be a rare thing to find at the end of any fiscal year a Local Hydro-Electric Utility that could honestly say its accounts receivable were 100 per cent. collectible—even though it is recognized that the Utilities are in a position to, and presumably do, restrict the time of credit to customers to sixty days. The bad accounts should be written off only with the approval of the Local Commissioners and thereafter such accounts should be transferred to a Bad Debt Ledger. Against the doubtful accounts remaining, and to some extent against the current accounts, a reserve should be set up. It would seem advisable to create such reserve to the extent of the full amount of the doubtful accounts with something added to take care of the current accounts. If some of the current accounts which look good at the end of the year—or for that matter at any other date—did not eventually go doubtful or go bad the Utilities would never experience any bad debts.

It is quite proper that a Doubtful Accounts Reserve should be created by monthly charges or appropriations out of revenue—at perhaps a rate per cent. of the gross sales—but there is no assurance that at the end of the fiscal year the reserve thus created will not be found short or over the amount required. The only way the adequacy of the reserve at any given date can be determined, is by an examination of the accounts receivable or, in the case of a larger Utility, by a study of its bad debt losses over an extended period.

Surplus

The true Surplus of a Municipal Hydro-Electric Utility can be determined only after all operating, maintenance and administrative expenses have been paid and after creation of each and all of the reserves

already mentioned herein. The fact that a surplus appears on the books of any Utility is not sufficient reason for failure to set up any required reserve. Some Utilities choose to call their surplus a "Stabilization of Rates Reserve" and for this they can hardly be criticised. It would seem proper to regard the free surplus of any Hydro-Electric Utility as available for the stabilization of rates or for the future moderation of rates should the surplus increase to such an amount as would justify such action.

INTEREST

In the handling of their interest charges the Local Hydro-Electric Utilities do not amortize and write off any discount on debentures. Under conditions other than those obtaining on Hydro-Electric Utilities such treatment of discount on debentures would be open to criticism. The fact is, however, that by the provision for debt retirements and sinking funds the Local Utilities provide out of operating revenue over the life of the debentures, for the payment of the full par value of such debentures. By such provisions the full amount of the debenture liability is eventually covered and there is no necessity to also amortize the discount. When the debentures have all been retired it is proper for the Utility to write the amount standing in the Discount account off against the Debenture Retirement Reserves.

RESERVE FUNDS

It would seem permissable for a Utility to employ the funds made available by the creation of its Depreciation and other Reserves,

(a) As working capital—to whatever extent required.

(b) For investment in plant—to the extent of a portion but not the whole of such Reserves.

From time to time there is a demand for portions of such funds to meet the very purposes for which such funds are created—such as Renewal of Plant, Public Liability Claims. Contingencies, etc. The demand for such funds may come at a time—and the present is a good example—when neither the Local Utility Commission nor the Municipality (in which the Utility is located) can readily or economically make funds available by bank borrowings or debenture sales or otherwise. It is therefore strongly recommended that a reasonable portion of the reserve funds be kept in liquid form by the investment thereof in bonds of the Dominion of Canada or of the Province of Ontario or other marketable securities. It is appreciated that a goodly number of Local Hydro Utilities have already invested surplus funds in liquid securities and to these the recommendation would not apply except to the extent that a portion of such securities might well be earmarked as the investment of reserve funds. To all other Hydro-Electric Utilities the caution is advanced that all of their reserve funds (over and above the amount required for working capital) be not invested in plant or other fixed assets. If so invested they may be found to be frozen when they are required for the very purposes for which the reserves were created.

Accident Prevention—An Executive Responsibility

By Wills Maclachlan, Electrical Engineer, Toronto

(Presented before Engineering Section, New England Division, National Electric Light Association at Boston, March 4, 1932)

IN trying to think through the problem before us, viz: Accident Prevention—An Executive Responsibility, it would be well for us to get a clear conception of what are the functions of an Executive. The most general function I feel is to get the job done. This applies, whether the executive be President or Foreman; whether the job be running a circus or a bank. You, however, are Executives of a public utility. The job you must get done is a job that extends into the future. Ten years from now the utility may be called to answer for how you got your job done this year and hence your chief function is to get the job done in such a way that it will stand for a number of years. This applies, whether the job is the development of a public policy, the design and construction of a plant or the sale of electrical utensils to a housewife. The job must be done, not only with the view of the present but as far as possible with that of the future.

Another function of the Executive, and closely connected to the first, is to give leadership and inspiration to those carrying out the details of the job. Driving and depending upon a fear instinct is not only inefficient but frequently reflects upon the inherent ability of the user as an executive. We can therefore look to the executive for leadership and inspiration in developing a broad policy looking into the future and to the results of the policy as to the best way to get the job done that we have in hand.

Let us look now at the other side of the problem. What are the results of an accident? An employee who receives personal injury by accident arising out of and in the course of the employment cannot produce, and loses his wages and requires medical and surgical treatment. Society has decided that these costs or a large part of them shall be borne by industry on the theory that the costs of an accident of industry shall be borne by industry. I fully realize that some will say that it is the action of politicians, but an examination clearly shows that many countries since the first of the present century have placed Workmen's Compensation Acts on the statute books showing that the feeling is world wide. These vary in many ways but for the most part the injured employee, during his lay off on account of the injury, receives compensation and the medical fees are paid. If he is killed his dependents are pensioned or some form of recompense paid, the costs of the accident being borne either by the individual industry or a group of similar industries. If there are no accidents there are no costs; if few accidents the costs are low; if many

or severe accidents the costs are heavy.

As a result of an accident, usually there is also plant destroyed. Quite naturally the humane instincts subordinate this to the human injury but the sum total of destroyed or damaged plant as a result of accidents is by no means a small item. The operation of the wrong disconnecting switch may result in severe burns to the operator but the short so originated may cause much material damage.

The accident usually results in disorganization of the staff. If the injury is severe, there is the excitement among those immediately present. There is then the time absorbed in the talking about the accident by employees, as well as the time of officers investigating the cause. Often there is the necessity of replacing at least temporarily, the injured man and frequently his retraining for a different class of work must be carried out. The more important the injured man is in the organization, the more widespread is the disorganization.

These results of an accident, however, fade into insignificance when compared to the worry and suffering of the man and his family. One has only to have been brought personally in contact with the family of an injured man to forever remember the situation.

For the compensation and medical fees, industry pays; for the destroyed plant, industry pays; for the disorganization of staff, industry pays; but for the worry and suffering of the injured employee and his family, who pays?

It would therefore seem, that if the industry is to be carried out efficiently, some consideration should be given to these preventable costs. It certainly is someone's job.

Turning now to methods that have been found effective in preventing accidents. The first steps to be taken deal with material things. Tools and equipment must be carefully selected so that the work can be done safely. As an example, the lineman's belt should receive attention. By redesign, laboratory tests and field experience much improvement has been made recently. Guards should be placed around dangerous points. An example of this is the necessity of a guard around electrolytic lightning arresters, connected on a "Y" circuit having the outside of tanks at time of discharge at a dangerous potential above ground. Then by design of new plant, precautions should be taken that it shall be safe to construct and operate. An example would be the placing of baffle-boards between the blades of disconnecting switches and arranging for the clear marking and numbering of each piece of equipment. An indication only is given of methods to be followed.

In all organized society, rules are necessary for the safe and orderly carrying out of duties. To prevent accidents, clear, simple and workable rules are necessary. Of most general use in public utilities is the rule that expressly states how a piece of apparatus or line shall be taken out of service to be worked upon. This we call a "Mark-up". These rules should be limited to essentials and as few as possible to get the job done safely. In the development of them,

the assistance of the field force is of the greatest importance.

Instruction and training are possibly the next steps to be taken. In the development of the instruction of a staff, care must be taken not to neglect what may appear simple but is most important. For instance, how many linemen, line foremen, station maintenance men or for that matter, supervising engineers, fully realize the necessity of a low resistance ground of good carrying capacity where a ground is to be used? Do all recognize the hazard of a faulty ground connection? Instruction, therefore, should be complete and thorough. Closely allied to instruction is training. After instructing in the effect of the passage of electrical current through a human being, and explaining the necessary amount of simple physiology, the employees should be trained in and required to practice the Prone Pressure Method of Schafer. Quick application by well trained crews who will not lose their heads, being of utmost importance in saving life.

Surely one would say that with well designed and constructed tools and plant, clear and adequate rules and well instructed and trained staff, accidents will be eliminated. Experience has taught us that at least two other matters are necessary—leadership and discipline. If there is a rule made, either enforce it without fear or favor or abandon the rule. The greatest care must be exercised in formulating the rule and later in enforcing it. Leadership, usually of the right kind, automatically does away with the necessity of severe discipline. Psychologists tell us that "two pats on the back to one kick in the pants, is about the correct mixture."

We find that the Executive is the man who, by his leadership and inspiration, gets the job done and in him is vested the authority to issue orders in light of his experience and his broader view of the future. In his particular sphere, he is the best judge of the practical means to be used to gain a particular end. Special advice may be obtained if necessary from those expert in engineering, sociology, physiology and psychology. These special phases of the work should find expression through the Executive and so keep the prevention of accidents as a part of the job and not as something entering from without. The prime object is to develop methods whereby the job can be carried out efficiently and safely. The Executive is vested with the authority and his is also the responsibility.

Other phases of the prevention of accidents, such as the selection of men, selection and training of junior executives, health instruction, etc., might well have been touched upon but possibly come more directly under the broader aspect of industrial relations.

So far we have been dealing with accidents to employees. Has the Executive a broader interest? In the use of electricity in factory and home, has he an interest? What effect on future sales has an accident with an electrical device in factory or home? Has the sales force completed its job until it has explained the safe way to use a device, let alone sure that the device sold is safe to operate? Yours

is not a fly by night industry. Have these questions, as far as your responsibility for a stable industry, been satisfactorily answered?

The Executive not only has a responsibility but has also a wonderful opportunity. A plant and staff safe from accidents is usually an efficient plant and staff. The opportunity of protecting the lives of ones fellow-workers, is no mean thing to offer a man. There is something satisfying in being engaged in a work that means the protection of the happiness of those for whose work one is responsible.

This is your opportunity.

Come out of your offices and the prestige of your positions into the world of men—your men—and by giving leadership and inspiration, help solve some of the problems of a distressed world. Yours is the personality, the education, the training, the responsibility and the opportunity.

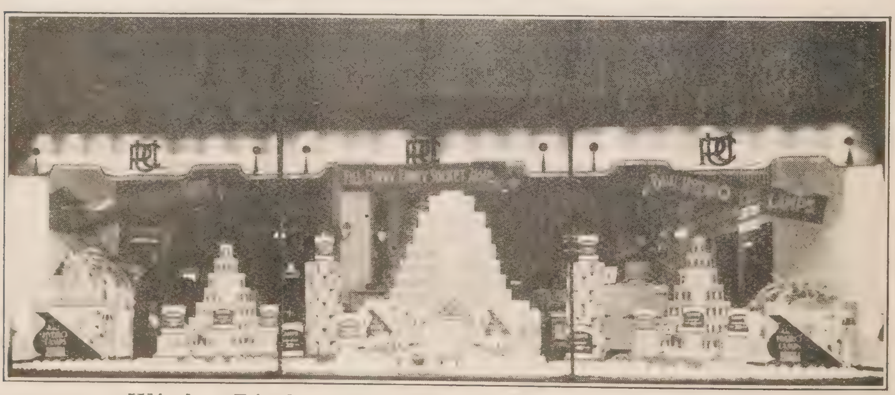
Commissioner W. S. West, Woodstock, Honoured

At a Meeting of the Public Utilities Commission of Woodstock held on February 11, 1932, W. S. West, K.C., a Commissioner for fifteen years, formerly withdrew from that Board. Mr. West was elevated to the Bench as Judge in Haldimand County, Ontario, recently, and had tendered his resignation from the Commission under the date of February 8.

"The resignation was accepted on motion of Mr. W. A. Smith and Mayor Johnston, not however without regret being expressed by each member of the Board at losing Mr. West. The members were also unanimous in extending congratulations to Mr. West on the signal honor that has been conferred upon upon him.

"In reply, Mr. West thanked the members for their kind words regarding him and his part in bringing the system to its present state of efficiency, paying tribute also to members of the Commission even prior to the date of his service on the Board."

In recording this event, we also add our congratulations to one with whom, as a Commissioner, it was always a pleasure to have dealings, trusting that he may be long spared to grace the office to which he is elevated.



Window Display, London Public Utitities Commission.

Water Power Resources of Canada

(Excerpted from Bulletin 1573 of Department of the Interior, Dominion Water Power and Hydrometric Bureau).

IN view of the importance of Canada's water power resources it is desirable to take regular stock, not only of the extent of these resources as a whole, but also and, perhaps more particularly, of the progress in their utilization. For this reason the Dominion Water Power and Hydrometric Bureau, Department of the Interior, is constantly revising its data concerning these resources as new physical data become available and also at the end of each year collects information and compiles a statement of the new installations completed during the year and of the work done on new hydro-electric enterprises. The results of this compilation are issued annually by the Bureau in the form of bulletins.

During the year just closed, business conditions led to a somewhat reduced demand for power. This reduction, however, had little or no effect upon the programme of hydro-electric construction which was maintained without interruption. In the past the supply of hydro-electric energy, owing to the time necessary to carry an enterprise through to production, has had a tendency to lag behind the demand and it is, therefore, not unreasonable to believe that as normal business conditions return the power to be made available by current construction will be speedily absorbed.

This activity in construction has been of great value under existing conditions because it has afforded much employment, not only at the actual site of development, but also in the factories furnishing machinery and other supplies required in the enterprise. It is conservatively estimated that the installations actually completed during 1931 have resulted in an expenditure for the generation, transmission and distribution of the new power developed of not less than \$110,000,000, while an additional \$280,000,000 will be required to bring the plants actually under construction to completion. These figures alone are an index of the extent to which hydro-electric construction is contributing to ameliorate the present situation.

A detailed discussion of recent installations throughout Canada has already been issued by this Bureau in a bulletin entitled "Hydro-Electric Progress in Canada during 1931". This shows that there was a net gain in turbine installation of 541,325 h.p., a figure that has only twice been exceeded, and that the total installation now amounts to 6,666,337 h.p. Great as this installation is it represents only, as will be shown later, 15½ per cent. of the present recorded water power resources of the Dominion. A brief summary of the present situation in regard to the water power resources of Canada is contained in the following paragraphs.

Basis of Computation of Available Water Power

The figures for available water

power listed are based upon rapids, falls and power sites of which the actual drop or the head possible of concentration has been measured, or at least carefully estimated. Many unrecorded rapids and falls of undetermined power capacity exist on rivers and streams from coast to coast. These will only become available for tabulation as more detailed survey work is completed; this is particularly true in the less explored northern districts. Also, no consideration has been given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power dams, unless definite studies have been carried out and the results made matters of record.

In brief, the figures hereunder are based on definite rapids, falls and power sites, and may be said to represent the *minimum water power possibilities of the Dominion.*

The power estimates have been calculated on the basis of 24-hour power at 80 per cent. efficiency for conditions of "Ordinary Minimum Flow" and "Ordinary Six Months Flow". The "Ordinary Minimum Flow" is based on the averages of the flows for the two lowest periods of seven consecutive days in each year, over the period for which records are available. The "Ordinary Six Months Flow" is based upon the continuous power indicated by the flow of the stream for six months in the year. The actual method to determine this flow is to arrange the months of each year according to the day of the lowest flow in each. The lowest of the six high months is taken as the basic month. The average flow of the lowest seven consecutive days in this month determines the ordinary six month flow for that year. The average of such figures for all years in the period for which data are available is the ordinary six month flow used in the calculation.

Estimates of power on the basis of ordinary six months flow are made upon the assumption that it is good commercial practice to provide installation up to an amount, the continued operation of which can be assured during six months of the year, with the deficiency in power during the remainder of the year provided from storage, by interconnection with other plants on streams of different regimen or operating under different load conditions, or by the installation of fuel power plants as auxiliaries. The correctness or otherwise of this assumption for any particular site can only be definitely settled by careful consideration of all circumstances and conditions pertinent to its development. The method, however, enables a fairly satisfactory over-all estimate of the maximum hydraulic power available, to be made as distinct from the estimated ordinary minimum power available.

TOTAL AVAILABLE AND DEVELOPED WATER POWER

The known available water power in Canada, from all sources and within the limitations outlined, is 20,347,400 h.p. for conditions of ordinary minimum flow and 33,617,200 h.p. ordinarily available for six months of the year.

The conservatism of these estimates

is demonstrated by an analysis of the water power plants scattered from coast to coast concerning which complete data are available as to turbine installation and satisfactory information as to stream flow. The analysis shows the average machine installation to be 30 per cent. greater than the ordinary six-month flow power. Applying this, the figures quoted above, therefore, indicate that the present *recorded water power resources* of the Dominion will permit of a turbine installation of about 43,700,000 h.p.

The total installation to date in water wheels and turbines throughout the Dominion is 6,666,337 h.p. In other words, the present turbine installation represents only about *15½ per cent.* of the recorded water power resources.

Water Power in the Central Electric Station Industry

About 98 per cent. of the output of central electric stations in Canada is generated from hydraulic installations. The proportion of hydraulic installation available for public use is steadily growing to keep pace with the increasing demand for domestic, commercial and industrial energy. In all three of these fields new adaptations are increasing the demand. The development of the alternating current radio, electrical refrigeration, therapeutic appliances and general household devices in the domestic field, of improved commercial lighting and advertising in the commercial field and of electro-chemical and electro-metallurgical processes in industry constantly increases the demand on the central electric stations.

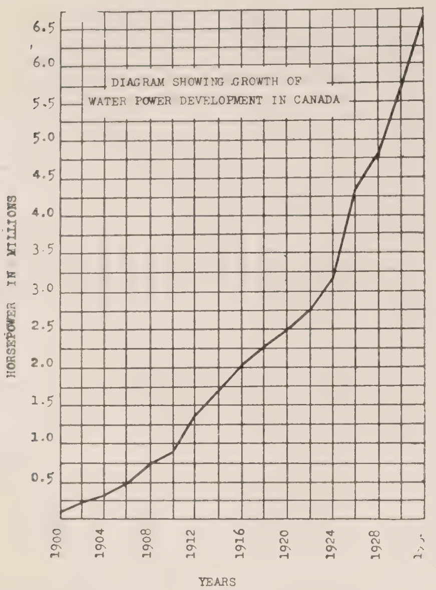
At the present time there are 328 hydro-electric central stations in Canada with a total installation of 5,734,491 h.p. Of these totals, 226 stations with an installation of 609 turbines of a combined capacity of 4,241,838 h.p. are owned by commercial organizations while municipal or other public organizations operate 102 stations which contain 242 turbines, aggregating 1,492,653 h.p. The average installation of the commercial stations is 18,769 h.p., and the average capacity of their turbines 6,965 h.p., as compared with 14,634 h.p., and 6,168 h.p., respectively, for the municipal stations.

Individual turbines vary in size from the 10 h.p. turbines used for hamlet lighting to the great 65,000 h.p. units of the Chute a Caron development on the Saguenay River.

Water Power in the Pulp and Paper Industry

The occurrence of large supplies of pulpwood in close proximity to substantial water powers has enabled Canada to take a commanding position in the pulp and paper industry. The power demands of the industry are large, approximately 100 h.p. per ton of daily output of newsprint being required, and the low priced power afforded by hydro development is an essential factor in economic operation. A further advantage of the use of water power by the industry lies in the utilization of surplus or off-peak power in electric steam boilers for the production of process steam.

The pulp and paper industry itself has an hydraulic installation of



600,996 h.p., of which 321,643 h.p. is connected to electric generators, while additional hydro-electricity is purchased to operate a motor installation aggregating 993,024 h.p., making a total of 1,594,000 h.p., used in the industry, of which more than 82 per cent. if hydro-electric.

Past and Future Growth in Water Power Development

The remarkably rapid growth of water power development in Canada is illustrated by the diagram herewith. It shows that the total installed horse-power has grown from 890,489 h.p. at the beginning of 1910 to 6,666,337 h.p. at the beginning of 1932. In the same period water power installation in central electric stations grew from 586,502 h.p. to 5,734,491 h.p., and in the pulp and paper industry from 115,042 h.p. to 600,996 h.p.

Capital Invested in Water Power

The capital invested in water power development in Canada, inclusive of transmission and distribution systems, is estimated to be more than $1,514,000,000 and of this almost $1,370,000,000, or almost 91 per cent, has been expended on land, buildings, plant and equipment. This is greater than the capital investment of any other manufacturing industry and is an investment with a most creditable record for safety of principal and stability of earnings.

Coal Equivalent of Developed Water Power

While it is very difficult to assign a precise figure of the coal equivalent of developed water power owing to lack of definite information as to operating conditions in the individual plants, the saving of coal through the utilization of water power is very great. Comparing water power development in Canada with similar development of fuel power elsewhere, a conservative estimate indicates that each installed hydraulic horse power, if operated continuously throughout the year, would effect a saving of about five and one-quarter tons of coal, or that the present total installation of 6,666,337 h.p. is capable of effecting a saving of approximately thirty-five million tons of coal per annum.

The actual saving in any year depends, of course, upon the actual kilowatt-hour output of the plants during the year. Based upon the actual output of central electric stations, it is estimated that the equivalent electrical production of the total water power installation in 1931 was approximately 19,200,000,000 kilowatt-hours. Applying to this a conservative figure of 1.62 lb. of coal

per kw-hr. (based upon the average consumption of coal and coal equivalent per kw-hr. during 1930 by all plants in the United States producing electricity for public use) indicates an actual saving for the year 1930 of more than 15,500,000 tons of coal.

Radio Inductive Interference

Bulletin No. 2, "Radio Inductive Interference", by H. O. Merriman, p. 104, published by Radio Branch, Department of Marine,—35 cents.

This publication was primarily intended as an instruction book for government radio inspectors and describes in simple form the causes of radio inductive interference. The first section describes how interference from a spark or fault on electric lines or apparatus reaches the radio receiver. The section following deals with tests by which an electrician may identify radio inductive interference and trace it to its source. The first tests are of a very simple nature conducted without special detection apparatus and would probably enable an electrician to deal with many of the simpler cases. The more difficult cases require special apparatus, and such details and methods of procedure are fully explained.

The chapter on radio receiver installation will be of interest to broadcast listeners and radio service men as it gives many useful suggestions covering the installation of radio receivers, aerials and ground connections.

Means of suppressing radio interference are then described in detail commencing with the theory of surge traps and followed by specifications for the construction and application of surge traps for many types of electrical apparatus.

A chapter on radio interference from equipment and lines of public utilities then follows, dealing first with simpler apparatus such as telegraph keys and telephone ringing equipment, and continuing with electric railway and distribution systems. The cause of interference from high voltage transmission lines is, also, covered, including interference from corona and brush discharge.

The last chapter gives a few examples of interesting cases recently dealt with by government investigators.

The book is written in a style which can easily be understood by electricians and, at the same time, includes a description of the principles underlying the causes and means of suppressing radio interference which should be of interest to engineers. A complete index is added which makes the book convenient for reference.

New Illuminants Have Much Merit

Some European Developments that Supplement the Regular Functions of Incandescent Lamps.

By Ward Harrison

One question (in two or three parts, it is true) springs up perennially in the minds of all lighting men, particularly at the beginning of a new year:

> "Is our business stabilized on a definite basis or are new illuminants destined soon to supplant those to which we are accustomed; are new schemes and methods of lighting soon to replace our familiar lighting fixture designs, and if these things are to happen, what will be the effect on our business?"

The editors have asked me to attempt at least a partial answer to the general question, based for the most part on what I have had an opportunity to see recently in visits to the principal lamp and lighting laboratories of Europe.

First, as to illuminants, we have been subjected to persistent rumors of late, principally via the technical press, as to new light sources of fabulous efficiencies, developed abroad and soon to be introduced on the American market. In several European laboratories I did see gaseous-conductor tubes from three to six feet in length and 1½ in. to 3 inches in diameter for which efficiency figures of 35 to 50 lumens per watt were quoted—that is about 2½ times the efficiency of modern incandescent lamps. These tubes gave either the characteristic green light of mercury vapor or the red light of neon. The candlepower ratings ranged from 2,000 to 6,000 candlepower and their energy consumption was between 1,000 and 2,000 watts. The lamps operated directly from lighting circuits, preferably 220 volts, with no transformer or other auxiliary apparatus except the ballast resistance (or reactance) which is essential to the operation of arc lamps of all types. These powerful lamps are by far the most efficient producers of red light and of green light that have been developed, and a combination of tubes in the proper ratio results in a nearly white light which will be found acceptable for many purposes. Please note that a combination of tubes and not of gases, was stated; up to the present time no efficient and satisfactory means has been found to produce white light from a mixture of gases confined in the same tube.

The extent of the application which these new lamps will find for themselves in this country depends largely upon the demand which develops for spectacular and colored lighting effects. The consumption of electricity of "white light units"—2,000 watts or more—is so great that until artificial illumination reaches much higher foot-candle levels than at present, the use of these combinations of tubes will be seriously limited. For example, in America sixty or seventy 200-watt tungsten lamps are sold for each 1,000-watt lamp, and the call for 1,500 and 2,000-watt lamps is but a small fraction of the demand for 1,000-watt units.

In addition to the 1,000 and 2,000-watt neon and mercury units, these illuminants are also available in lower wattages — 300 to 500 watts — in tubes usually about one inch in diameter and perhaps three feet long. These likewise can be combined to produce a substantially white light. However, the efficiency of these smaller tubes is not greater than that of tungsten lamps of comparable size; in fact it is usually less, and there is no economic advantage in using them for ordinary purposes of light production. They will, of course, be of value in the field of colored lighting. The mercury tubes are also being tried out abroad in combination with tungsten-filament lamps to produce a whiter light than is obtainable from the latter when used alone. If in this combination a proper ultra-violet-transmitting glass is used for the tubes, there results a very fair reproduction of daylight as regards both the visible and invisible spectrum. Some experimental work has been done on gaseous tubes in sizes even lower than 300 watts, but as the tubes are made smaller the efficiency falls off rapidly, and even the most optimistic of the men in the laboratories concerned with these developments are of the opinion that nothing now in sight is likely to compete successfully with the tungsten lamps in sizes of 100 watts and below.

Besides the mercury and neon tubes there is one other gaseous illuminant of considerable promise and that is the sodium vapor lamp; such lamps have been made which show efficiencies as high as 70 lumens per watt, in sizes as low as 300 watts; that is, for 300 watts an output of 1,700 candlepower is claimed, and for the 150-watt size about 500 candlepower. These efficiencies are unequalled in our other light sources, and if it were not for the peculiar characteristics of sodium, these lamps might well be considered as the most important of all new lighting developments. Unfortunately sodium gives a monochromatic light which is very definitely unpleasant—more so than mercury light to many persons. It seems to require very great dilution with other illuminants before this disagreeable effect disappears. Again, the tube must be kept very hot in order to secure efficient operation. This usually means that the tube itself must be sealed inside of another evacuated tube which acts as a heat insulator. Finally, sodium vapor is exceedingly active chemically and attacks both glass and the metal leading-in wires. Both must therefore be special and expensive. For the present, therefore, it would seem as though the field for sodium lamps would probably be confined to the lighting of very large areas (as in street lighting) with high-power lamps where economy is a great consideration and color is unimportant. In such cases the inherent efficiency of the lamps has its best opportunity to make up for its high manufacturing cost and other handicaps.

As to the progress which these various types of illuminants have made in Europe up to the present time, it should be understood that we did not find any of these lamps in service in an actual installation; they are all in the laboratory stage and in each case the men responsible for their development state that more

time is required to perfect them in operating details before they will be ready for the market. It is interesting also to know that in the case of nearly all of the light sources I have mentioned in this resume, at least an equal progress in development can be seen in American laboratories, and notably in the laboratories of the General Electric Company.

Regarding new methods of lighting in Europe, space permits of but little discussion here. As I have said on one or two occasions before, it seems that in America we are just now reaching the point where in the minds of the majority of architects and fixture designers it is recognized that modern electric lamps actually do not smoke; that they do not burn with a flame which must be guarded as a fire hazard; that they do not require oxygen for their operation; in a word, that they do not necessarily need to be hung out in the centre of the room two or three feet below the ceiling, but that they can even be built into the wall if desired. It would appear that the Europeans were quite a bit ahead of us in grasping this absence of limitations in modern light sources and they are trying to push ahead and to hold their advantage if they can.—*The Magazine of Light.*

Unique Levelling Method

The Soviet Union is full of unusual things, among them what may be the oldest irrigation canal in the world. It diverts water from the Arax River in the vicinity of Erivan, Armenia. According to a stele in cuneiform, it was built about 900 B.C. The stele tells of its construction by a certain king or chief and then proceeds to call down a curse on anyone who destroys either the stele or the canal. It seems to have been effective as a means of protection, as the canal is still in operation, although the stele has been cracked by an earthquake.

The Armenians have also a unique method of canal location called "goat levelling." They have discovered that a goat will neither go uphill nor downhill unless he has to. When they wish to build a canal, they take a goat to the vicinity of the proposed intake and turn him loose in the right direction. The goat traverses the contour and they peg down after the goat. It is a simple and satisfactory means of securing the grade since if the canal does not work they can blame it on the goat. Wise old Armenians! It is a pity we cannot employ a goat on more complicated structures.—*Civil Engineering.*

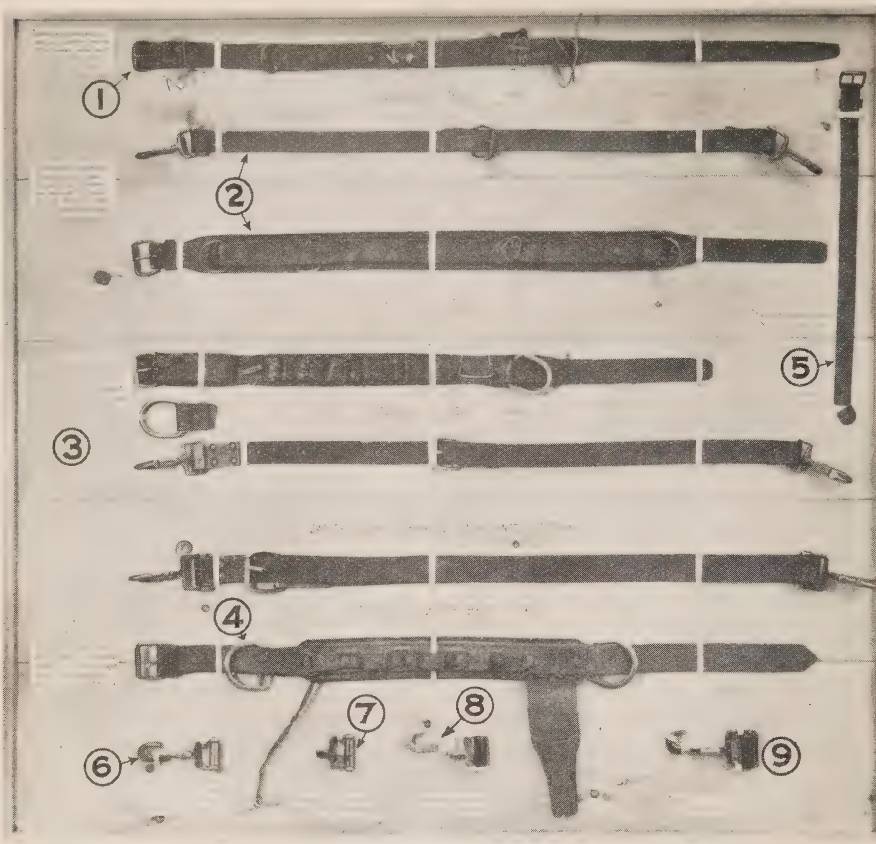
Association of Municipal Electrical Utilities

Report of Committee on Accident Prevention and Health Promotion

A meeting of this Committee was held at Mr. Wills Maclachlan's office, 55 Murray Street, Toronto, on Friday December 4, 1931, at 10 a.m., at which the following places were represented: Windsor, Chatham, London, The Toronto Hydro-Electric System, The Hydro-Electric Power Commission and Mr. Wills Maclachlan from the Electrical Employers' Association. Discussion was very general and started from the report unanimously adopted by the Association of the Municipal Electric Utilities at its convention in January, 1930. This report had been tentatively outlined at the Convention of 1929, and had been printed in booklet form with the title "Line Work", and was sent to all municipalities in the Province with a letter asking for their comments and criticisms during the year 1929. It was condensed, and very few criticisms were received from the municipalities of the Province; and as it stands now it comprises the main headings for a great part of our line equipment with its use, as well as an actual statement of work which may be carried out by different classes of linemen. To date the committee has been unable to find out whether the method of workmanship as laid out in this report has been adopted by the various municipalities, and the committee feels that not enough attention is being given to the various phases of accident prevention as applied to the municipalities. The municipalities, except in a very few places, are very lax in getting the various safety devices and using them, and the committee feels that some method should be adopted whereby these various municipalities can be reached and convinced that accident prevention work will repay them in dollars and cents.

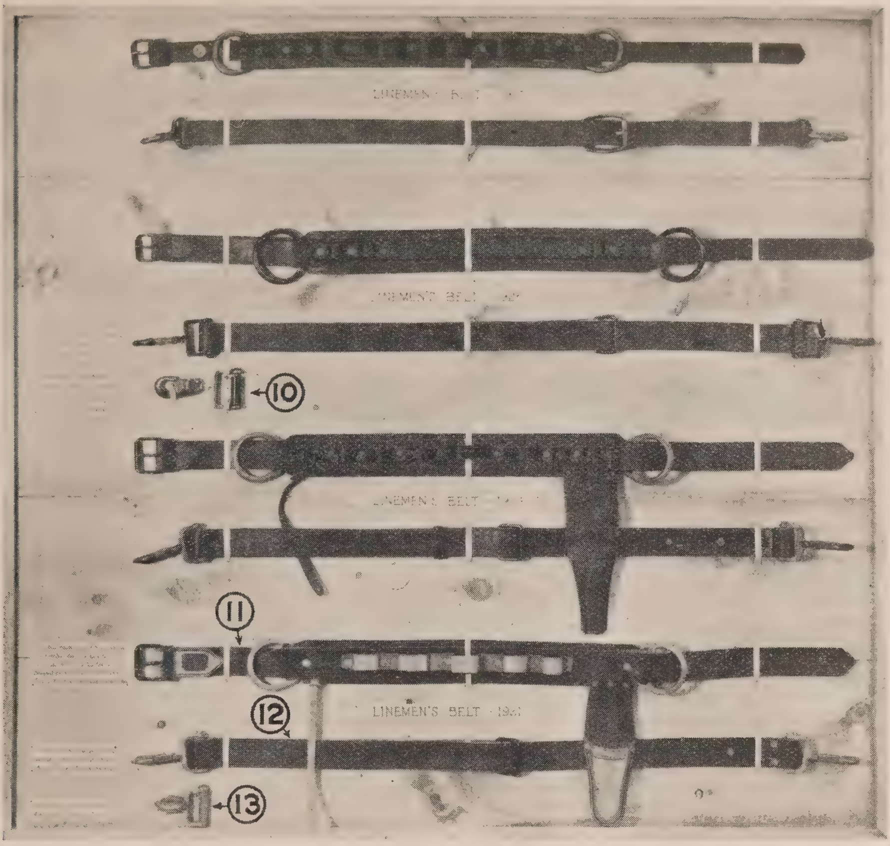
We have discussed various methods for reaching all municipalities, exclusive of the larger cities, where accident prevention meetings are held very frequently; and are endeavouring to set up a system whereby these various municipalities could be brought together in small groups and work and equipment discussed there. Mr. Wills Maclachlan is endeavouring to to go over his list of municipalities and pick out men who will be interested enough to spend some time and see other men in these smaller municipalities in their district with a view to holding small meetings, possibly monthly or bi-monthly; at which the men can be talked to and convinced of the necessity for this work. This scheme is being tried out and the success will be reported next year.

The information on various kinds of safety equipment which is available is being condensed under different headings, such as:—linemen's belts, rubber gloves, gogles, rubber blankets, etc., and Mr. Maclachlan is making up a booklet containing all this information together with recommendations regarding the use of



1. Small D's fastened on outside, inferior metal. Wire hooks, make-shift metal tool keepers, spliced leather. 2. Malleable iron snaps. Note tests on these. Small D's fastened on outside, inferior metal. Make-shift wire attachments. 3. Poor maintenance and partial destruction of belt by attachment allows D ring on strain to pull out. Lineman using belt at the time, died of injuries received. 4. By make-shift wire, attachment at D ring of standard belt weakened leather so that D pulled out. It was caught inside body belt. No accident resulted. 5. Example of destruction of leather when heated to 140 degrees Fahrenheit. 6. Malleable iron snap which broke in cold weather when man was at crossarm. 7. Malleable iron snap which broke. Man 4-ft. from ground. 8. Bend test of malleable iron snap in laboratory. 9. Tension test of malleable iron snap in laboratory.

same; and also the best places where it can be obtained. This will be available to the A.M.E.U. very shortly, and each municipality can get a copy of it for reference, particularly when buying new equipment. Discussion also took place at the meeting regarding linemen's school along various lines: First—where linemen are put in special gangs for instruction, Second—the correspondence course with men brought together at intervals. This method would be, perhaps, feasible where



10. Malleable iron snap showing a similar snap that broke while lineman was using belt 35 ft. from ground. 11. Selected bark tanned leather; drop forged steel. Large D rings on inside of belt. Moulded tool keeper. Shaped plier holster. Belt numbered. This is the present standard lineman's belt. 12. Selected bark tanned leather; drop forged steel snaps; wrought iron buckle. 13. Bend test on drop forged steel snap in laboratory.

there are only a few men in small municipalities.

Discussion also took place regarding equipment and the possibility of setting up exhibits at the Convention of various types of equipment showing the standard type and various examples of other types which have failed in service. An exhibition of belts, broken in various ways, will be set up at the January Convention, together with various other pieces of apparatus, and men will be available there to explain the reasons of certain types of equipment. and the committee feels that this should cause a greater interest to be taken in purchasing standard equipment.

* * * *

Report of Committee on Research

There is little that I can give you in connection with this Committee, other than to report progress.

However, there are some developments in connection with the Committee's work which have taken place during the year. You will remember that the Committee was formed with the idea of urging upon the Hydro-Electric Power Commission the necessity of work being done in their laboratory along the lines of research for the distribution and utilization of hydro.

It was felt that in the past the major part of the work of the Commission's laboratory has been done in connection with generation and transmission. You remember at the Summer Convention a report was made setting forth quite an extensive list of problems that might be investigated.

However, up to the present, one of these only has been tackled. This is the problem of domestic water heating. Mr. Barnes of the Hydro-Electric Power Commission has been continuing his investigations and has made considerable progress on the correct type of installation to be made for domestic water heating.

The other part of this is the development of some scheme whereby water heaters could be controlled from the sub-station at the will of the chief operator or load dispatcher so that these appliances would not come on the peak load.

There were three schemes considered. First, the use of a supervisory control wire; second, momentary interruption of the load supply, sometimes known as "winking" the circuit; third, the use of voltage superimposed, of the higher frequency for control purposes—what might be called a carrier current system of control.

The conclusion arrived at is that the third of these methods is the only practical one.

At this time it does not seem advisable to give much publicity to what has been done. The Commission has pretty well arrived at a solution of the problem and on Friday morning, any of the municipal men who are interested in this will see at the laboratory a demonstration of the apparatus which has been developed for this purpose.

There is, perhaps, a somewhat peculiar situation in connection with this. I believe the Chief Engineer and the Municipal Engineers of the Commission are not quite convinced that this control of peak loads should be gone into extensively. The reason for that is, I suppose, due to the fact that municipalities are now paying for power on a peak load basis and that any attempt by any one municipality to produce a flat load curve would increase the cost of power distributed to the municipalities and would put an undue penalty on the municipality with the poor load factor.

The solution is, of course, to change the type of rate and to adopt a rate which would include a service charge based on the peak load, plus kw-hr. charge. The other objection is, I presume, that off peak power is now being sold by the Commission.

However, it appears to me—I may not have the right slant on this—that the objection is not valid. When Sir Adam Beck and his associates first looked at Niagara Falls and thought what could be done with this great

natural resource, they didn't just simply think of the question of giving to the people power at a lower cost than was being given by private companies but they saw the great advantage of this recourse in bettering living conditions in the home and making for more economical working conditions in the factory.

Now, if domestic water heating is a good thing for the housewife to have and if she can afford to pay the price, then I can't see why the municipalities shouldn't have that off peak power. I have been very much interested in this whole development which I think is very worth while and before the Summer Convention we will have something very definite to put before you.

Report of Municipal Hydro-Electric Pension and Insurance Committee

1.	Number of Municipalities included	41
2.	Number of Employees Insured	2,058
3.	Amount of Life Insurance benefits in force	$4,262,730.00
4.	Amount of monthly service annuity being purchased	93,850.22
5.	Amount of monthly income annuity being purchased	53,631.00
6.	Municipal Authorities, 5% monthly payments	14,228.00
7.	Employees' monthly income annuity contributions	7,360.00
8.	Employees' monthly extra contributions	167.92
9.	Number of death claims paid up to October 28, 1931	27
10.	Amount of death claims paid up to October 28, 1931	51,080.00
11.	Employees' Income Annuity contributions refunded	4,426.00
12.	Employees' Extra Contributions refunded	80.88

The Secretary drew particular attention to the amount of money which had been paid out in death claims during the 2½ years that the System had been in operation, which meant that the dependents of the 27 employees who had died during that time had received an average of almost $1900 per family, which, no doubt, had done much to relieve the necessities of these families, and give them some comforts that without this insurance they might have been deprived of.

He urged that all Municipal Commissions that had not already taken advantage of this system, give it their earnest, serious consideration, as in addition to providing security for men who had given years of loyal service, it also tended to stabilize labour conditions, as men with some guarantee for themselves in later years and for their families in the event of death, have a feeling of security that is of material advantage to their employers.

THE BULLETIN

Published by
HYDRO-ELECTRIC POWER COMMISSION
of Ontario

190 University Ave.
Toronto

Subscription Price $2.00
Per Year

Wood Pole Transmission Lines

A Discussion of Recent Modifications in Construction as Outlined at the H.E.P.C. Formen's Conference

By E. G. Archer, Assistant Engineer, H.E.P.C. of Ont.

AN outline was given at the December Conference of the Construction Foremen of some objectives sought in recent modifications which have been made in wood pole transmission line practice. It was thought that the foremen would, by being familiar with the reasons for and the objectives sought in any revision, be in a better position to further the purpose of the conferences, *viz.*,—to attain the closest possible co-operation between the office and field.

Based on the operating experience of the Hydro transmission system, improvements in the design or construction are made from time to time as considered advisable. Some of these revisions are briefly reviewed.

It has been found where wood pins have been used at voltages above 22 kv., that considerable pin digestion has occurred, resulting by the breakdown of the wood fibre in the formation of a soft white cap on the top of the insulator pin which allows the insulator to be pulled off. For this and other reasons, on recent pin type construction, the use of steel pins has been specified. These pins are fitted with a lead thimble and wide flat base. In the case of the lead thimble on the steel pin, it is important that the thread conform to the details of the thread in the various insulators used. The result of using improper thread is shown in Fig. 1, where it is noted that an insulator, during erection, has been split through the centre from top to bottom. This fault was corrected by the deepening of the valley in the lead thread and the narrowing of the thread, itself, in order that the lead could then more readily flow into the grooves in the insulator. The prompt reporting of this defect by the men in the field resulted in immediate correction and demonstrates the value of co-operation.

Following considerable trouble with insulator ties, the present standard provides for the use of the "pigtail"

CONTENTS

Vol. XIX **No. 4**

April, 1932

tie. The flat armour on the conductor has been omitted because it was found that it was difficult to make a tight tie and moreover, the tendency on the part of the linemen to roll the armour wire resulted in the hardening of this wire creating hard sharp edges which cut into the conductor.

It has been the practice, until recently to make the joints in the smaller sizes of aluminum conductor by means of twisted sleeves. As the load carried by these lines increases, it has been found that under short circuits, these sleeves "explode" with the result that the conductor is burned off. In Fig. 2, it is to be noted that the fault occurs throughout the entire length of the sleeve. For several years the conductor has been painted before being inserted in the sleeve and precautions have been taken to seal the end of the sleeve

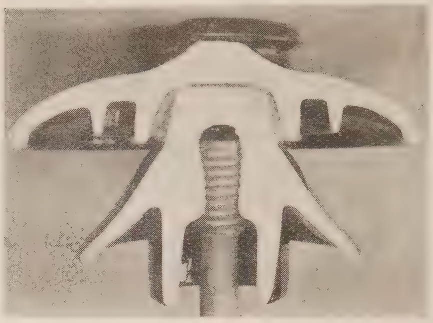


Fig. 1.--Broken Insulator due to improper fit of pin.

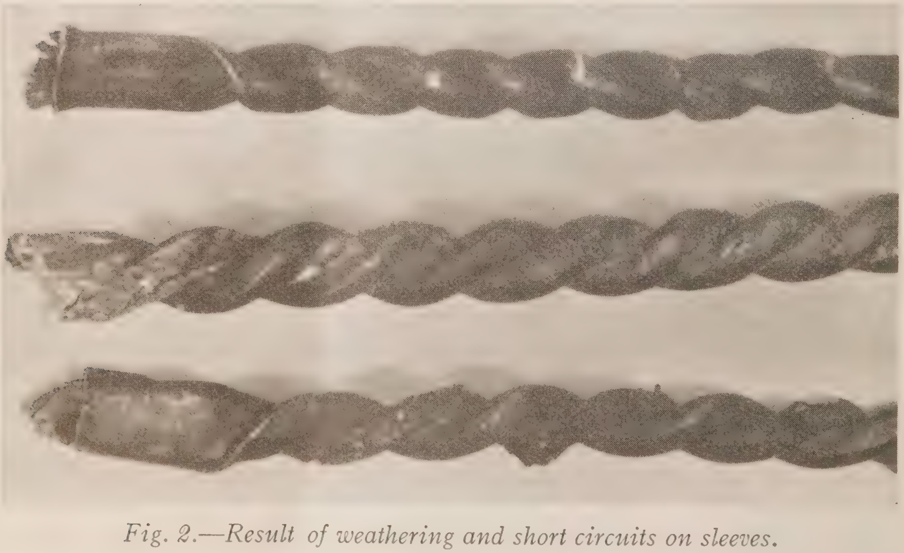


Fig. 2.—Result of weathering and short circuits on sleeves.

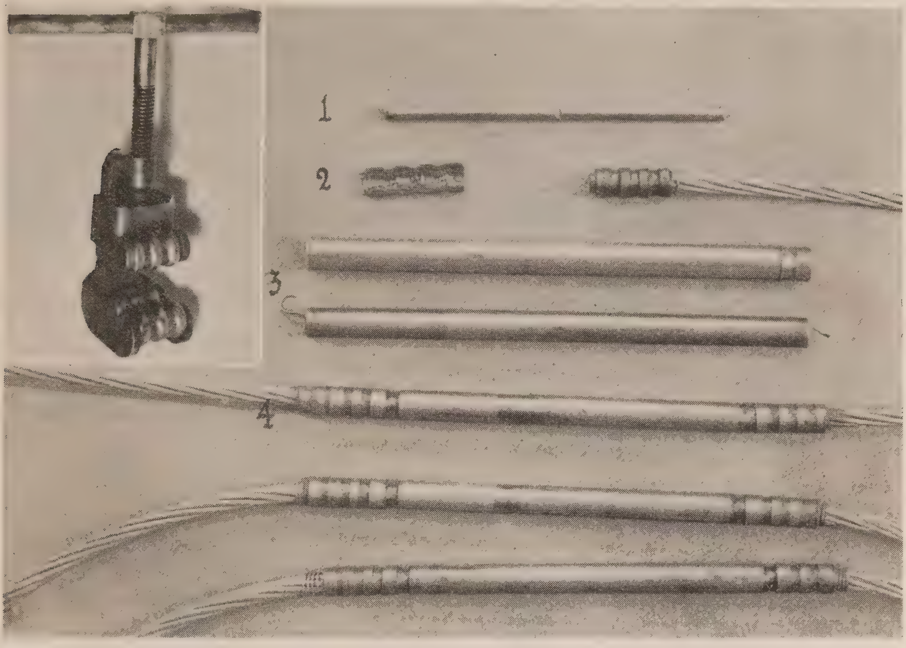


Fig. 3.—Rolled type of joint.—(1) Steel sleeve with piano wire coil; (2) Sleeve cut after rolling; (3) Tinned copper tube fitted inside with coiled brass wire; (4) Completed Sleeve. Insert—Type of roller used.

against moisture, after twisting and serving. Recently, we have been trying a rolled sleeve, one type of which is shown in Fig. 3, where the steel core is first joined for tensile strength and then a tinned-copper sleeve for conductivity is rolled into the conductor ends by means of suitable rollers. It is thought that this type of sleeve will form a gas-tight joint and will reduce to a minimum faults similar to those which occurred within the old type of twisted sleeves. It is also found under the present requirements for our telephone lines that a dependable and uniform low resistance joint is required. This is particularly true in the case of trunk telephone circuits, where phantoms are generally installed. The successful operation of the phantom always requires an accurate resistance balance of the two physical circuits. In the case of telephone conductors for long span work, an unusual type of 7-strand cable is sometimes used, consisting of 1 strand of aluminum as core for conductivity, surrounded by six strands of steel for strength. The usualy twisted tinned-copper sleeve joint has been found unsatisfactory for this type of conductor and a sleeve is being developed that will provide a suitable electrical joint for the aluminum core as well as a connection of suitable mechanical strength for the steel envelope. One type of such sleeve is shown in Fig. 4.

In the last few years an effort has been made on some wood pole lines to use experimentally the high in-

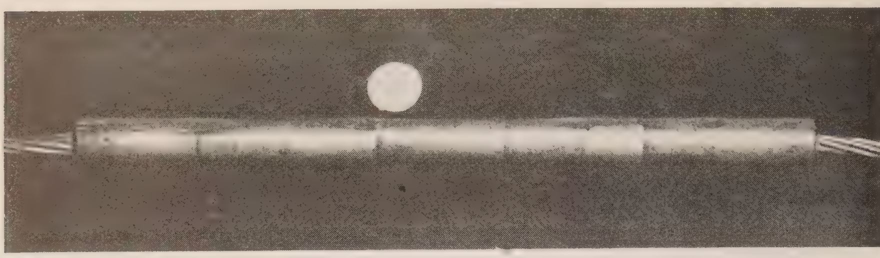


Fig. 4.—Sleeve used on aluminum core, steel cable for telephone circuit (No. 6 A.C.S.R. reversed). A small sleeve is compressed on the core, the outer steel sleeve being installed by hydraulic press.

sulating value of the wood arm and pole to reduce the effects of lightning. This has resulted in the replacement of the usual steel braces with wooden braces for supporting the cross arms, and also in the use of long wooden insulators in the guys. Both braces and wood guy insulators are made by our Production and Service Department. The braces have a wood cross-section of 1 in. by 2 in., and the guy insulators 2 in. by 2 in. Both are fitted with suitable hardware for transmitting the strain to the wood. The wood guy insulators are capable of withstanding a tension of over 10,000 lb., and have a lightning flashover value of approximately one million volts. Under certain conditions, the wood strain insulators are equipped with arcing horns to prevent shattering. On one installation, the 26-kv. line to Pottageville, a wood guy strain insulator attached to the pole immediately under a phase wire and which was not provided with arcing horns, was shattered by lightning but no outage occurred.

Fig. 5.—22 kv. line near Wiarton showing wood braces and wood guy insulation.

The extensive use of radio requires additional care on the part of line foremen to avoid any construction that tends to cause radio interference, e.g., the insulator tie must be left with the "pigtail" turned upwards and precautions must be taken that any grounding wire insulation or other metal part is either solidly connected

to, or always kept clear of all other hardware, such as bolts, on the pole.

The successful operation of the transmission lines on the Hydro System is to a large extent dependent upon close co-operation between the departments responsible for design, construction and operation. It is hoped, therefore, that the annual meetings of the field and office forces will materially further the aim of the Commission in maintaining the best possible service to the municipalities.

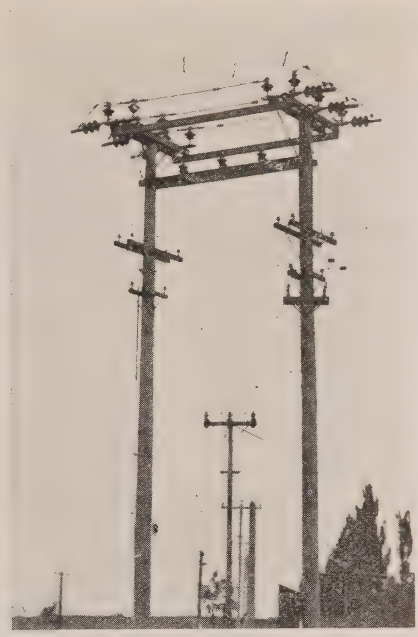


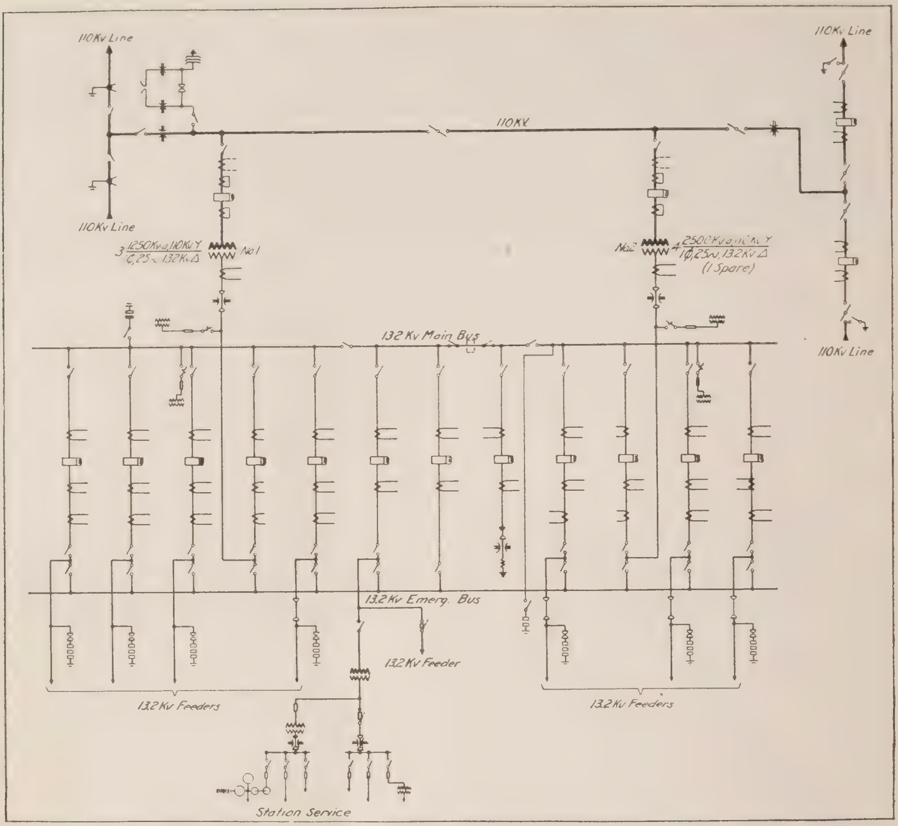
Fig. 6.—Switching point near Tara showing copper being used to reduce number of insulator supports.

Woodstock Transformer Station Extension

By B. C. Platt, Assistant Engineer, Electrical Engineering Dept., H.E.P.C. of Ontario

THE extension to this station was constructed to supply the increased load in the Woodstock district, and to provide heavier duty 13.2 kv. oil breakers. The station is now designed for an ultimate transformer capacity of 30,000 kv-a., and is of semi-outdoor construction, the transformers and control room being housed in the original building while the 110 kv. switching on the two incoming and the two outgoing lines, also all of the 13.2 kv. switching is installed outdoors.

The 110 kv. type "GA" line breakers were removed from inside the station to make room for the second bank of transformers. These breakers were replaced by type "G22-AA" breakers installed outdoors on a steel structure, erected to accommodate one 110 kv. line which was brought around the north side of the station.



Woodstock transformer station, wiring diagram.

The new transformer bank consists of three 1250 kv-a., 1 phase transformers which are installed as a second bank in new pockets in the existing high tension room. The station now has two banks of transformers, one of 3—1,250 kv-a. capacity and one of 3—2,500 kv-a. capacity, giving a total of 11,250 kv-a. capacity, with a spare 2,500 kv-a. unit so connected that it may be used with either bank in case of failure of any transformer.

The 13.2 kv. switching equipment was re-designed using an open type of bus and new type "CH-1" Westinghouse oil breakers. An emergency 13.2 kv. bus was provided and connected to the main bus through an emergency oil breaker. To accommodate the installation of the new 13.2 kv. equipment outdoors, a pipe structure was erected. This structure is 124 feet long, 28 feet wide and 20 feet high. It consists of 2 inch and 1¼ inch pipe of which there is approximately 2 miles used in its erection.

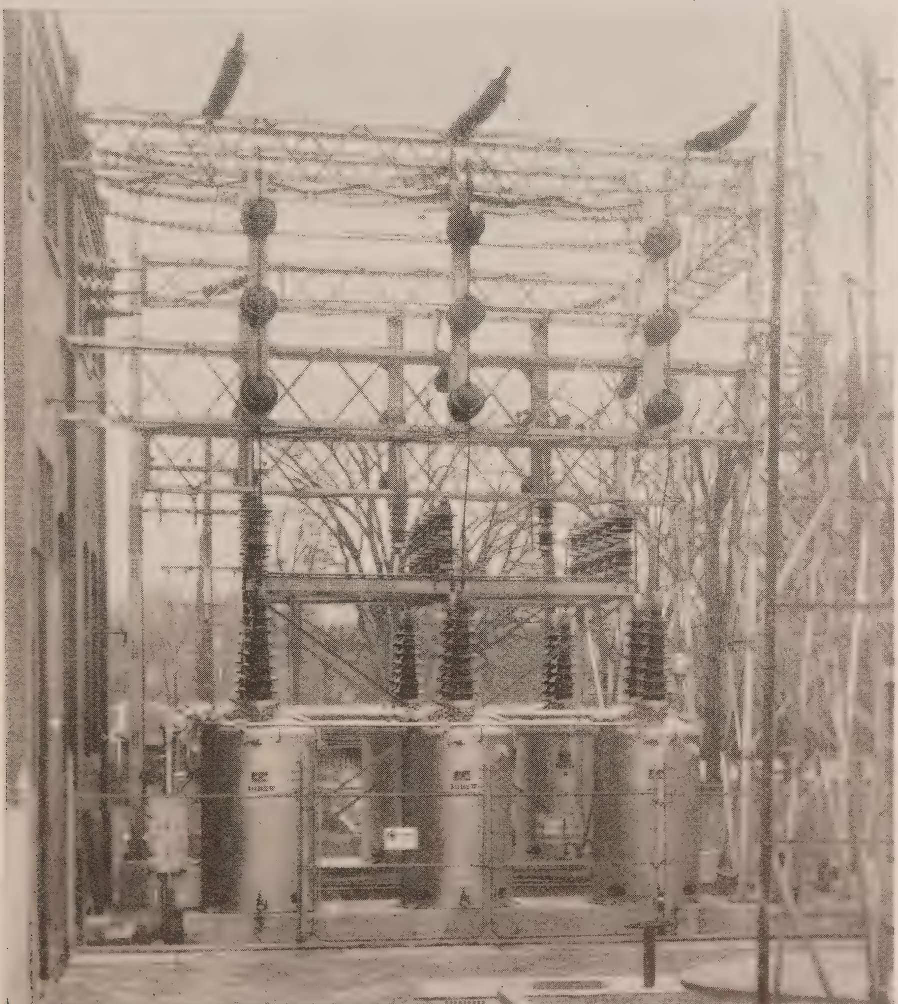
The 13.2 kv. feeder switching equipment consists of twelve feeder units to control two transformer feeders, one emergency feeder, one station service feeder, one ground selector and seven outgoing feeders.

The Woodstock Rural Station is served from the station service feeder and is located at this station.

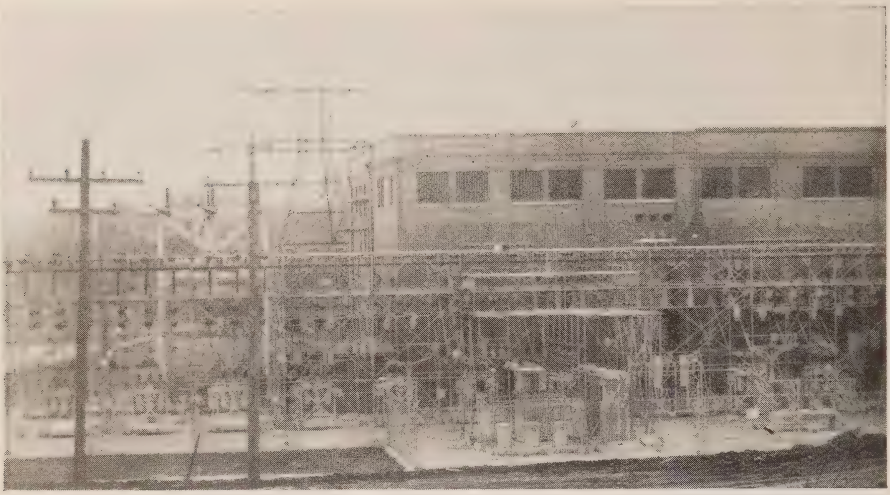
For lightning protection, one 110 kv., 3 phase, C.G.E. electrolytic lightning arrester is connected to the 110 kv. bus, while two C.W.Co. type "SV" 3 phase arresters are connected to the 13.2 kv. bus (one on each section) and a set of three 15 kv. single-phase, pellet type arresters per feeder is connected to each of the 13.2 kv. outgoing feeders.

A new control room was erected under the former 13.2 kv. lightning arrester gallery, the floor of which was extended 18 feet, making the control room approximately 60 feet long.

The station service equipment consists of two Moloney Electric 50 kv-a. 3 phase, 13,200/575 volt outdoor



Switching equipment on 110 kv. lines.



Woodstock transformer station, 13.2 kv. switching structure.

transformers and three Ferranti Electric 10 kv-a., 1 phase, 550/220 110 volt transformers with H.E.P.C. protective equipment, one 60 cell sealed type battery and a 2 kw. diverter pole motor generator set complete with all connections for lighting, heating and oil filtering systems and for the operation of all of the oil breakers.

Modern relay protection installed to cover the complete protection of the station, includes the following—(*a*) reverse power protection on one 110 kv. incoming and 110 kv. outgoing line, (*b*) transformer zone differential for short circuits or internal bank faults, (*c*) low voltage grounds transformer zone protection, (*d*) low voltage bus protection, current differential, bank distance and ground detector, (*e*) low voltage feeders current and distance, (*f*) ground selector. The relays were obtained from the Cansfield Electrical Works and the Canadian Westinghouse Company.

Three single-pole 13.2 kv. oil breakers of Canadian Westinghouse Co., manufacture were installed as a ground selector. Each single-phase breaker is connected between phase and ground through a water resistance. Upon the occurrence of a ground fault, the unbalanced ground voltage thus created on the three phases is made use of to select and close one of the ground switches of an opposite phase, thus completing a single-phase, short circuit by way of a ground fault. The fault current thus created will trip the faulty feeder.

Owing to the close proximity of this station to an artificial lake, the soil is of a wet nature, so special precautions had to be taken in the construction of the piping tunnel under the new transformer pockets, also of the manhole for the control cables as it was not feasible to drain them.

The north, east and south sides of the station have been graded and crushed stone placed under and around the structures.

The west side of the station is adjacent to one of the city parks.

A standard six foot chain link fence with suitable gates has been erected around the 110 kv. and 13.2 kv. structures.

This work has been carried out by the Commission's Construction Department and was placed in service on September 27, 1931, and will be completed early in 1932.

Geo. F. Shreve, General Manager, Oshawa P.U.C.

George F. Shreve

The position of general manager of the Oshawa Public Utilities Commission, rendered vacant by the death of the late Chas. T. Barnes, has been filled by the appointment to that office of Geo. F. Shreve.

Mr. Shreve's first association with utility work was when in 1911 he entered the employ of the Seymour Power Co. Ltd., under John Littlejohn, treasurer. From 1912 to 1916 he was accountant for the North Bay Light, Heat and Power Co. Ltd., at North Bay, which became the Nipissing System of the Hydro-Electric Power Commission of Ontario. From that position he enlisted with the Canadian Field Artillery for service overseas, and gained his commission in 1917 serving to the end of the war in the Royal Air Force. After returning from overseas he again entered the employ of the Hydro-Electric Power Commission of Ontario as accountant at Oshawa. When the City of Oshawa took over the local Gas and Electric utilities in 1927, he continued as such for the new local Commission. In May 1931 his duties were extended to include that of Secretary-Treasurer, and on March 31, 1931, was appointed General Manager.

Application of Hydro-Electric Power to Farm Work

Article No. 24

Electrically Heated Hotbeds

IN many sections of the country, the cost of manure for use in hotbeds is increasing and becoming increasingly difficult to obtain, forcing farmers to look to other methods of heating their hotbeds. Electrical heating of the soil has been applied to hotbeds, cold frames and propagating benches. The available reports of experiments and actual installations have indicated the feasibility of this method of heating and also demonstrated a number of advantages over the use of manure for this purpose, and other earth heating systems.

In the electrically heated hotbed, the temperature is automatically maintained and may be set for the most suitable temperature for the particular plants being raised. Soil temperatures of 45 to 70 degrees are usually recommended for hotbeds, the lower temperatures being used for growing cabbage, cauliflower and lettuce plants, a medium range for tomatoes and the higher temperature for peppers, eggplant and cucumbers.

Seeds germinate, plants grow and cuttings root in from 20 to 30 per cent. less time, substantial increases in the number of seeds germinated, and increases of from 10 to 50 per cent. in cuttings rooted have been reported, in fact rootings of cuttings have been successful by this resource where all other methods were total failures.

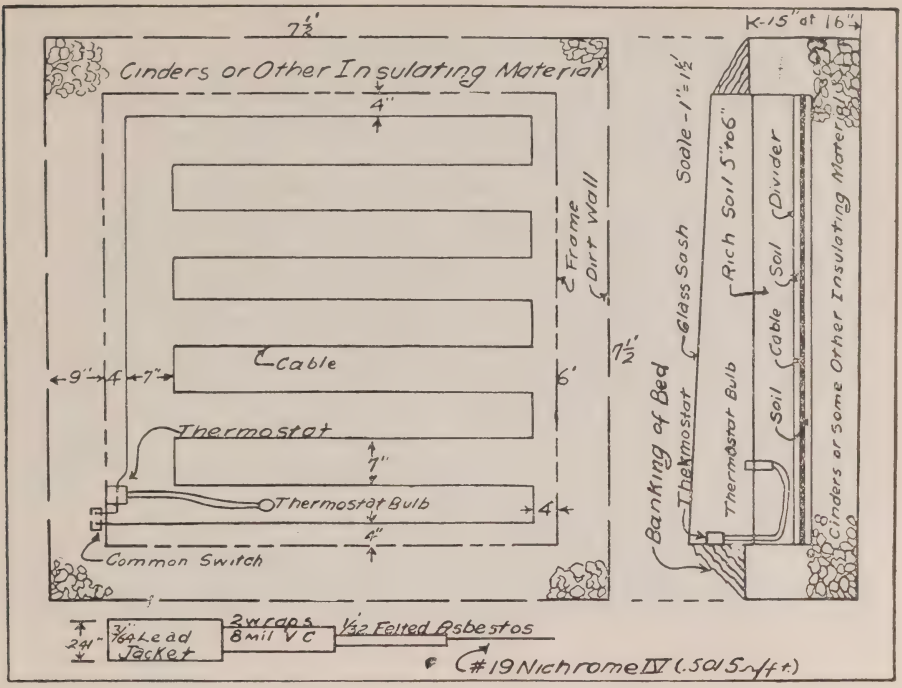
The ease of adjusting the temperature enables the grower to regulate the development of the plant. The hotbed can be readily converted to a cold frame for hardening plants by adjusting the thermostat to approximately 40° fahr.

With an electrically heated hotbed, it is unnecessary to rebuild the bed each year as in the case of a bed heated with manure. This results in an appreciable saving in labour and cost.

The heat is always available, whereas manure loses a large portion of its heating value, in from 4 to 6 weeks and is unstable.

Various methods of electrically heating the soil have been used and reported satisfactory. The method in general use is an insulated resistance wire with lead sheath buried in the soil and controlled by a thermostat. This equipment is simple, rugged and flexible, being readily applied to existing beds and should give years of service.

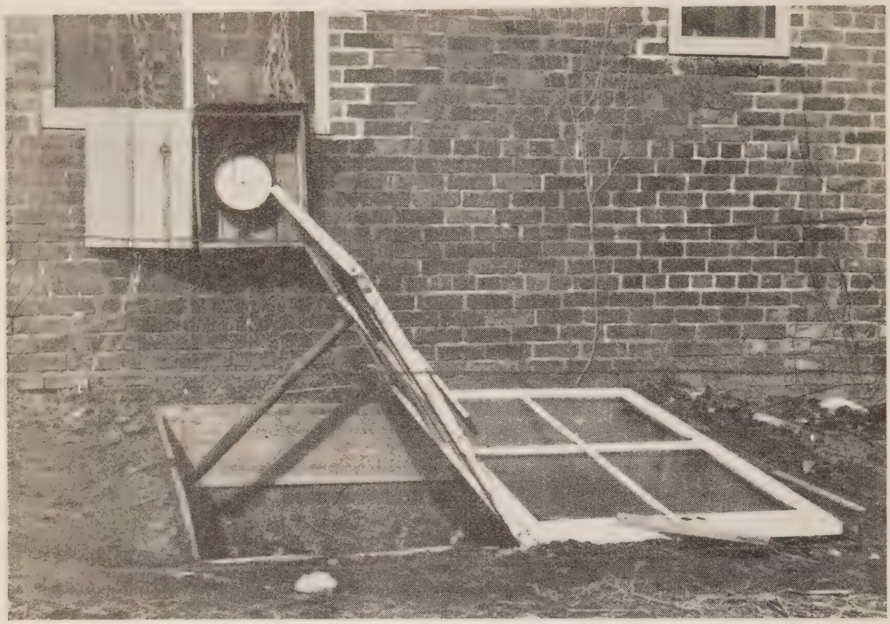
A demonstration of an electrically heated hotbed has been conducted by the staff of the Simcoe rural office through the courtesy of the Canadian General Electric Company, Limited, who furnished the equipment. This equipment for a bed 6 feet square consists of 60 feet of No. 19 insulated nichrome wire with lead sheath and connected across 115 volts gives a heating capacity of 400 watts or 100



Plan and section as recommended by the Canadian General Electric Company, Limited, showing construction as used in the experimental bed.

watts per square yard. A G.E. thermostat, CR-2992-D1, was also supplied with a capillary tube 2 feet long and a bulb 6.5 inches long, which can be placed in almost any desired location. This thermostat has a capacity of 15 amperes at 115 or 230 volts and one is sufficient to handle the heating of 8 sash (a bed 6 ft. by 24 ft.) at 115 volts or 16 sash (a bed 12 ft. by 24 ft.) at 230 volts.

A bed 6 feet square was constructed as illustrated in the accompanying diagram. A pit 18 inches deep was dug and in this was placed a wooden frame 6 feet square to take two 3 ft. by 6 ft. sash with a slope to the south to shed rain. Eight inches of cinders were then placed in the pit to provide insulation and underdrainage. Two inches of soil were then laid on the cinders and the heating cable laid as shown in the diagram. The cable should be covered with approximately one inch of soil and then a small mesh wire screen or expanded metal lath laid to protect the cable from damage when removing the top soil or the plants. The screen should be covered with 6 inches of soil. The thermostat was mounted on the inside of the frame with the bulb buried 4.5 inches in the soil and projecting 2 inches above the surface between cables and about 15 inches from the side of the frame. Three graphic thermometers were installed to record the temperatures of the outside air, soil temperature at a point 2 inches below the surface and the air temperature in the bed, at a point approximately 2 inches above



Hotbed used for demonstration, Simcoe Rural Power District.

the soil near the centre of the bed. A kilowatt-hour meter recorded the consumption and a graphic voltmeter recorded when the heater operated.

The bed was installed February 6 and the thermostat set for 55° minimum. The temperatures had reached an equilibrium on February 8 when radish, cabbage, beet and tomato seeds were sown. Leaf lettuce and tomato seedlings raised in a green house were transplanted to the hotbed at the same time. The radish sprouted February 10 and were ready for consumption March 19, a period of 41 days. Beets germinated February 15 and on April 2 were 6 inches high. Cabbage germinated February 12 and were ready to transplant April 2. Tomatoes sprouted February 11 and were 3 inches high April 2 while the tomato seedlings were 4 inches high. On March 18 flower seeds were planted in flats and placed on top of the soil in the bed. Balsam calendula, stocks and marigold germinated March 21, delphinium, viola, ricinus and zinnia on March 23, asters and alyssum on March 25.

The consumption of power during the period February 6 to 29 was 129 kilowatt-hours or an average of 5.4 kilowatt-hours per day for the bed, or 1.35 kw-hr. per sq. yd. per day. This included the preliminary heating of soil. During the period March 1 to 31 the consumption was 143 kilowatt-hours or 4.6 kilowatt-hours per day, or 1.15 kw-hr. per per sq. yd. per day.

Some idea of the weather conditions prevailing during this period may be gathered from the following data. During the 24-day period, February 6 to 29, the minimum daily temperature ranged from 6° to 38° fahr., with

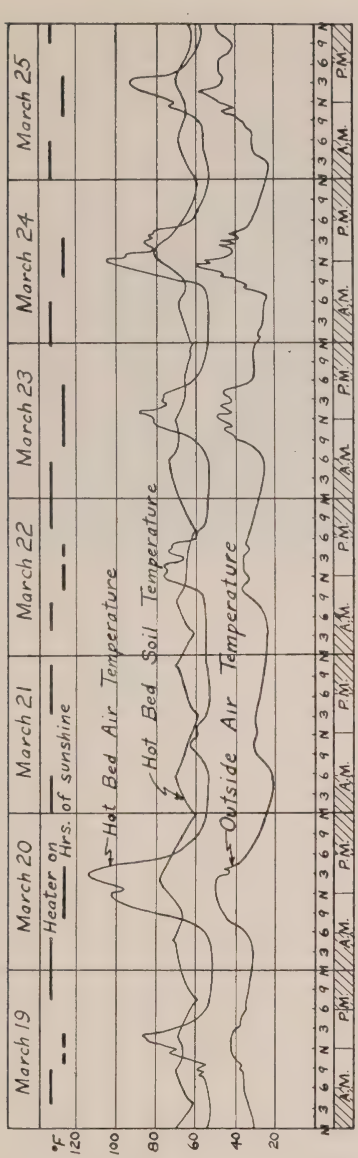


Chart of temperature records of a typical week.

one night at 6°, 8 at 10° to 19°, 5 at 20° to 29° and 10 at 29° to 38°. During this same period there were 17 days of sunshine with a total of 104 hours sunshine. During March the minimum daily temperature ranged 4° to 32° fahr. with 2 days with a minimum of 4° and 2 between 5° and 9°, 6 at 10° to 19°, 12 at 20° to 29° and 9 at 30° to 32°. There were 19 days of sunshine with a total of 125 hours.

During this period the minimum air temperature in the hotbed was never less than 52° approximately, and the setting of the thermostat 55°. Maximum temperature of 115° was recorded on warm days with bright sunshine, but was controlled by raising the sash and ventilating the bed. The soil temperature ranged from 60° to 72° except during periods of bright sunshine when temperature of 85° was recorded. The accompanying graph shows the relation of the temperatures in the hotbed, the hours of sunshine and the periods the heater was operating for the seven days, March 19 to 25.

In addition to the above demonstration, two 6 ft. by 6 ft. beds and one 6 ft. by 12 ft. bed have been installed on farms in the vicinity. Complete information in connection with these beds is not available. The 6 ft. by 12 ft. bed which was well constructed and insulated, equipped with sash and double glass, was installed March 15 and the thermostat set at 50° fahr. This bed was planted with tomatoes and peppers on March 22, and on April 14 the plants were 1.5 inches high. The consumption for the period March 15 to April 14 was 220 kilowatt-hours or 0.92 kilowatt-hour per day per square yard.

Complete data for a cost analysis of electrically heated hotbeds and cold frames, and those heated by other means, is not available at present. Edholm reports that the result of tests show one cubic yard of

Greenhouse and one of the new types of hotbed designed for steam heat.

manure is equivalent in heating value to 88 kilowatt-hours.

In considering the consumption reported for the demonstration bed, it should be borne in mind that this bed was operated in the higher range of temperatures, and was not protected during cold nights by covering the bed with matting or other material. This method is frequently resorted to in hotbed work and would result in an appreciable saving in the consumption. In cold frame work when protection against frost only is required, the consumption would be much less.

Since the above article was written two installations have been made on tobacco farms and are being used to raise tobacco plants from seed in outdoor beds covered with cotton. On April 16th, the outdoor temperature during the night was 20° fahr., the soil temperature in a bed heated with 5 inches of manure was 30° fahr., and the next morning this bed was covered with frost. In the electrically heated bed, the soil temperature was maintained at 50° fahr., and there was no sign of frost. Data in connection with these beds are being collected and it is intended to make this application the subject of a future article.

Collected information on this work was in the Bulletin December 1930, "Electric Heating of the Soil."

Lamp Efficiency in Lighting

By Geo. G. Cousins, Illumination Laboratory, H.E.P.C. of Ontario

(*Presented at the Industrial and Commercial Lighting Course held by the Electric Service League, Toronto.*)

IN the following, the term "lamp efficiency" is not restricted to its use as an expression of the lumens per watt but is used in a broader sense to include its place and operation in a lighting system. The lamp is the heart of a lighting system and in order for it to accomplish its purpose satisfactorily, the system must be designed and installed so as to provide it with the conditions under which it was designed to operate.

An incandescent lamp is a very sensitive piece of apparatus. Its design is a compromise of several opposing factors which may be varied so as to favor some at the expense of the others. The final choice is based upon the combination of quantities that result in economical production of light. Although lamp users have no control over these quantities, the wiring system determines whether or not the users will receive the efficient service that they pay for. For the purpose of this discussion, the voltage of current supplied to the lamps is taken as the governing factor in the operation of a lighting system. Lamps are designed for operation on definite voltages and when operated at their rated voltages the best results are obtained (with a few exceptions that are unimportant here). When the voltage departs from normal, a change is produced in all the other quantities and unfortunately, the most important quantities from the lighting view point undergo a much larger change than the voltage. The curves of lamp characteristics show the magnitude of these changes with changes in voltage. Attention is directed particularly to the large percentage change in light-output (lumens) for a given change in volts, 10 per cent. change in volts produces about 30–40 per cent. change in lumens, the corresponding change in watts is only about 15 per cent. The importance of this will be emphasized later.

The flow of current through a wire is always accompanied by a loss or drop in voltage which becomes greater as the current or the distance through which the current flows becomes greater. Good practice has placed the limit of drop at 2 volts. In the design of a lighting system a certain illumination intensity is considered necessary for a given requirement and the light-output values of lamps that are to be used are based upon operation at normal voltage. The resulting intensity is thus dependent upon the voltage at the lamps which in turn is dependent upon the carrying capacity of the feeder and circuit wires.

One of the greatest obstacles to efficient lighting to-day is due to the erroneous idea that the Electrical Codes specify standard grades of wiring for the various loads. As far as the carrying capacity of wires is

concerned the code is only intended to prevent the wires getting hot enough to set fire to a building. This must not be confused with the protection to life and limb demanded by the code through adequate insulation. The carrying capacity of wires are minimum values based on safety only. No. 14 wire will safely carry 15 amperes any distance but beyond 25 feet the voltage drop exceeds 2 volts. For a distance of 50 feet, No. 10 wire is necessary to carry 15 amperes and keep within 2 volts loss. The loss for 15 amperes on No. 14 wire at 50 feet is 4 volts. By referring to the characteristic curves it will be seen that at 96 per cent. volts the loss in light is 13 per cent. and the reduction in watts only 6 per cent. While there is a saving of 6 per cent. in watts there is a net loss of 7 per cent. in light which is paid for and not obtained. In other words 7 per cent. of the watts consumed and paid for do not give light.

There have been no appreciable changes in allowable carrying capacities of wire in the last 15 years, while in that time illumination intensities have increased 3 or more times. As a result code-wired buildings were probably adequately wired for lighting at that time but since the code requirements are still the same it is obvious that they are far from adequate at the present time, and will be still more so in another 15 years. Consequently a disregard for adequate provision for future needs will result in still more inefficiency.

The most prevalent cause of inefficient lighting systems is the limiting of the wiring to the lowest possible cost. A building space so wired may be required for work needing a higher intensity of illumination than that provided for by the original design. The logical result is an attempt to increase the intensity by the use of larger lamps. This naturally results in greater loss of voltage, thus producing a serious loss in lamp efficiency. The net result is that while an increase in illumination may be secured, the cost will be out of proportion to this increase as the increase in illumination is much smaller than the increase in wattage. It has actually been found that an increase in rated wattage of lamps has so increased the loss in volts that the illumination from the larger lamps was lower than that from the smaller lamps. This was an extreme case but the cause was obvious and it may happen at any time unless proper provision is made for reasonable increases in intensity.

The amount of increase to provide for is subject to individual judgment but it is generally considered that a doubling of the initial intensity is a wise choice. This can be obtained for less than 25 per cent. increase in the cost of the wiring. After a building is completed such an increase in capacity would be practically prohibitive in cost in a great many cases. The useful life of a commercial building is estimated at about 25 years and based upon experience of the past decade it is not too much to expect that the general level of intensities will be doubled in 25 years.

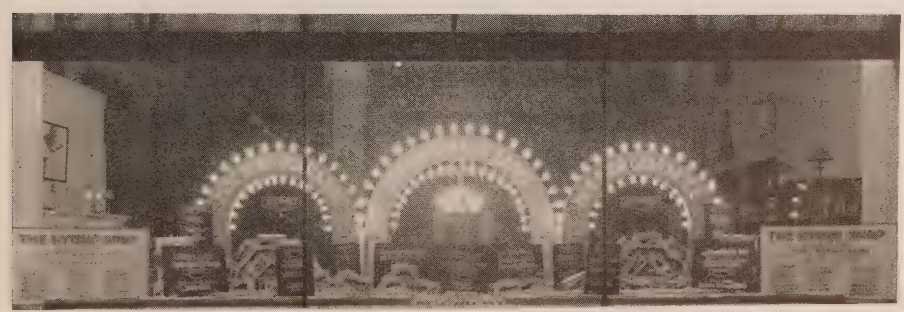
Lighting is good or bad according to its effect upon the eyes that must work under its influence. The most important phases of vision as affected by illumination are: acuity of vision;

speed of discrimination between objects varying in size, color or brightness; ability to maintain clear seeing and speed of adjustment for objects at different distances. All of these functions are improved with increasing intensities and with whiteness of light. If lamps burn appreciably below their rated voltage they produce a light which is relatively yellow as compared to the color at normal voltage. There is thus the double advantage of providing normal voltage for the lamps as the task imposed upon the eyes is made easier in two respects. This is important at any time but the importance of normal efficiency and its attendant color and high intensity are greatly increased when the artificial light is mixed with daylight such as late in the afternoon or at locations not close to windows. The conflicting colors of daylight and unmodified artificial light are very confusing to the eyes as they find it impossible to completely accommodate themselves to either color and any means of decreasing this color difference is of distinct value.

Incandescent lamps are carefully designed for the class of service that they are intended for, are manufactured with the utmost care and when operated under normal conditions give excellent results at a minimum of cost per unit of light. Like any other piece of apparatus when operated under sub-normal conditions, loss and uneconomical operation are the inevitable results.

The human eye is a delicate organism but will render faithful service if given the proper conditions for its normal functioning. When injured by faulty lighting conditions the damage can never be completely repaired and must remain as a handicap. The trend of life is such as to place increasingly greater burdens on the eyes. The eyes of youth are the most easily damaged and sub-normal eyes receive more benefit from good lighting than do normal eyes. Here again is a double virtue in providing the best possible illumination.

Advantage should be taken of every means of counteracting those influences and conditions that lower the efficiency of a lighting system and of the lamps in particular.



Woodpeckers and Overhead Line Poles

By Clifford W. Creatorex, F.Z.S.

THE fact that woodpeckers have attacked creosoted poles is surprising, and, from a pestological view-point, of considerable interest. Creosote protects timber against attack from practically every living form of organism but, apparently, even this potent agent does not deter the woodpeckers from making their determined efforts to secure hidden insects.

Is it possible that the poles attacked were not creosoted as thoroughly as they might have been?

Woodpeckers are birds possessing a remarkable faculty for detecting the presence of insects. Without wishing to commit myself to any definite statement, I would venture the suggestion that, possibly, hidden deeply in the centre of the poles, where the creosote may not have permeated, are wood-boring insects. In the attempt to reach them, the woodpeckers would hammer away at the surrounding timber, irrespective of the creosote. Obviously when used as a hammer—or as a hammer and chisel combined—the bird's beak is tightly closed, and the strongly flavoured creosote could not touch the palate. The long tongue, inserted in the holes made by the beak, is probably not highly sensitive. This member is flicked in and out with amazing rapidity, the insects being secured by a sticky secretion with which the tongue is specially provided.

Before drastic measures are adopted for the prevention of the woodpeckers' attacks, it would be very advisable to make sure that the poles affected do not harbour concealed insects. The destructive activities of wood-boring insects in the heart of a pole, could easily lead to very serious consequences, not the least of which might be the collapse of the pole in a strong gale. By drawing attention to the existence of the hidden enemy, the woodpeckers may be rendering a valuable service.

Several different species of beetles, and some insects belonging to other orders, live in timber, and the depredations committed by some of them are detected only when the trouble has gone too far. By preying upon such pests, the woodpeckers are amongst the most useful of all British birds. According to many eminent naturalists, woodpeckers never attack timber that is absolutely sound. In support of this view, a wealth of convincing evidence has been collected.

Some months ago, a friend of mine complained that a woodpecker attacked the wireless pole in his garden. Instead of taking the trouble to ascertain the reason for the bird's seemingly harmful attentions, he shot it. Later, the wind blew the pole down. It fell against a wall. Examination showed that, beneath the surface, near the spot where the woodpecker had been at work, the wood was riddled by the larvae of a beetle.

The post had been tarred, but the enemy, already in residence, had survived. Naturally my friend declares that never again will he destroy a woodpecker.

—*Distribution of Electricity.*

The Lights of Sarnia

By Johnston MacAdams

It is rarely that articles written by authors living outside of Canada picture the elements entering into the Hydro structure as vividly as does Mr. MacAdams' "Lights of Sarnia". For this reason, as also the interesting manner in which the details are brought out, the article commends itself to us; hence its reproduction.

SITUATED on the bank of the broad St. Clair some distance north of Detroit is a busy little Canadian city named Sarnia. Many readers of the New Republic may have heard its name called out on trains dipping into a great tunnel under the river, on the route from New York to Chicago. Others doubtless have seen it from the deck of passing Great Lakes steamers by day or glimpsed its electric lights by night, necklaced in a double row along the water. This article is about the electric lights.

I propose to reveal the actual working out of the world's greatest municipally-owned super-power system in simple terms by showing it in operation in this my home town. The excuse for thus portraying the Ontario Hydro-Electric Systems rests in the fact that most discussions of the subject are heavily clogged by figures of millions of dollars and billions of watts, whereas the essentials of the thing can be easily understood from a sort of "Middletown" survey.

When the municipal union was first mooted in Ontario, more than two decades ago, to draw power from Niagara and wholesale it to a little group of towns and cities, Sarnia held aloof. Sarnia was already served by a privately owned plant on the shores of Sarnia Bay. The local rates did not seem high, as private-ownership rates go, and it was the general local opinion that the geographical location of the little city was rather too remote from the source of current to make it logical to join fortunes with the Hydro group. In order to do so it would have been necessary to buy out the local private company, pledge the city's credit for this and for a long stretch of transmission line westward from the main stem, as well as for a share of the latter.

"Play safe," counselled the wise ones. "Our privately-owned utility has an advantage over the inland places in cheap coal near water, and will show an advantage in commercial management. If we join, we stand to lose the taxes which the city gets from the privately-owned plant. We have no guarantee that the commission acting for the group can furnish us with power more cheaply than at present. It is all conjecture."

Seven years passed. Things happened. The little group movement

of a dozen municipalities became, by 1917, a big group of 143 municipalities before Sarnia climbed over the ropes and into the ring. The by-law was passed, the local utility was purchased, the full responsibilities were shouldered, and Sarnia found itself in the well-known electrical-utility business, with assets of nearly a quarter of a million, 89 per cent. in debt, or worse, with heavy annual pledges. The retail rate was fixed by the Commission. Unfortunately for the supporters of the project, the rate was found to be six cents and six mills to domestic consumers. The rate charged by the private utility had been six cents, and the private utility had contributed to the taxes.

However, by the end of the year there was a surplus of $8,000.00. The rate was dropped from six cents and six mills to five cents and two mills—and there was a surplus at the end of the ensuing year. The rate was cut once more, this time to four cents and seven mills, and the surplus jumped to $24,000.00. In the fourth year the rate was pared down to four cents and three mills and the surplus at the end of the year bobbed up once more, larger than ever—over $44,000.00. The snorters became discreet.

At the beginning of 1929, the commissioners perceived that they had not yet succeeded in sinking their rates to consumers low enough to conform with the diminishing ratio of costs caused by volume and economies. Two dollars was lopped off the power prices and a mill was lopped off both commercial lighting and the domestic rate. Nevertheless, at the end of the year, the commissioners found themselves confronted with almost the largest surplus of thirteen uninterrupted years of plus figures—a surplus of $43,334.46.

The panic year, 1930, is the period covered by the most recent official report. Rates for household and shop were not again reduced, but power prices were given a two-dollar cut. Once again the effort to keep prices low enough to avoid a surplus failed of its object. Consumption grew and costs diminished. The panic year closed for the municipal utility with flying colors and a surplus of over thirty-seven thousand dollars. There was an increase in all classes of consumers, and apart from the incidental surplus, the full statutory quota went into the sinking fund to free the plant from its original debt.

But what about assets and liabilities?

It will be recalled that when Hydro started in Sarnia the net debt amounted to 89 per cent. of the total assets. But at that time the assets were only $319,000.00. Now they have grown to $971,000.00. Is the percentage of debt still about 89? Not at all. At the close of 1929 it had fallen to 33 per cent. At the moment of writing it is again lower, something under 28 per cent. and dropping. The annual surpluses are applied to increase the assets, and the sinking fund item concealed in the charge for current nibbles continually at the debt.

Let us view our Middletown to see the effect of current at two cents and less—an average monthly bill of $1.89 per domestic consumer. When the private plant was taken over, the

average domestic user bought fifteen kilowatt-hours a month. To-day he uses ninety-seven. The commercial user (store lighting, etc.) then used seventy-five kilowatt-hours. To-day he is using 404. Power users then absorbed 1,014 horsepower; several local industries used steam power. In 1930 the horsepower sold was 5,536 —more than five times as much. "White coal" has supplanted bituminous.

By every standard of measurement (including a doubling of the number of customers) the utility has grown out of all proportion to the increase of population.

The population of Sarnia is 17,003. Out of the 5,245 places of residence, 98 per cent. are customers of Hydro. The city has cheap natural gas for cooking and heating but there are more than 900 electric ranges. Ice is available from Sarnia Bay and from an ice plant run by cheap power, but there are more than 250 electric refrigerators. There are Chinese laundries and steam laundries, as elsewhere in Canada, but Sarnia housewives prefer to use their 2,500 electric washers and 4,500 electric irons. The use of electrical conveniences runs in the same proportion. Sarnia is mainly the home of industrial and railway employees. In The 5,140 dwelling places (out of 5,245 in all) where the current is a member of the household, the smallest of worries is the monthly yellow bill for current. The minimum gross monthly bill, including service charge, may be as low as eighty-three cents, less a 10 per cent. cash discount. As a matter of convenience the bills are not monthly, but less frequently rendered. Even the full average bill of $1.89 would scarcely warrant the expense of a monthly rendering.

How about taxes?

Manager Phelps of the Sarnia Hydro was formerly connected with the privately-owned utility, and recalls the taxes which the private company paid and which the municipal utility escapes. His letter states:

"One of the main arguments of private owners against municipal owners is that the latter do not pay taxes. We pay taxes on 25 per cent. of the value of the lands used for Hydro purposes. If we charged the same rates as were charged by the private company which we took over in 1917, we could easily pay taxes. But at those rates the people of Sarnia would not have got their supply of current for the $318,862.06 which we collected, for example, in 1929. At the private rates referred to we would have been entitled to collect $1,056,586.18."

One might add that though the city treasury no longer receives certain tax money from the private utility, it also no longer pays out a tidy sum in the form of excess rates for city street lighting, waterworks pumping, etc. The city hall is but little out on balance. But the city itself is immensely the gainer, as the manager shows. Two-cent electricity and cheap power is a money benefit, directly or indirectly, to every one of the 17,003 inhabitants and to every front foot of property—residential, business or industrial.

But what about the commercial-power user? How does he fare? Let us check up on a statement,

frequently made on behalf of the United States privately-owned utilities, and though their rates are admittedly higher to the small user, they are comparatively lower than those prevailing in Ontario to the industrial user of power. Moreover, it is alleged that though the Ontario public utility grants a low rate to the small domestic user "in order to catch votes" it evens things up like Robin Hood by soaking the big fellows. Though one may admit that there is not the same spread between prices in the two power fields as there seems to be in domestic prices, this is far from admitting that the United States manufacturer is actually better off in power matters, or that the Canadian manufacturer is mulcted in order that cut-rate electricity may be distributed among the many.

An illustration of the actual difference in power rates may be obtained by comparing two industrial plants owned by the same United States interests. One plant, located at Sarnia, is a customer of Hydro, while the other, at Port Huron, Michigan, just two miles away, used Detroit Edison power. Reports showed that the Port Huron plant paid $14,625.44 for a certain month's power, whereas the same power, if bought at the Sarnia factory, would have cost $11,311.17. This is a difference of $3,314.27 in a month, or enough in a year to pay six per cent. on half a million, but the difference really is more, for the Sarnia price covered a contribution to a sinking fund tending to lower future prices. The month used for comparison was August, 1926. Sarnia power rates have gone down at least twice since then, and in 1929 the price in Sarnia for the identical block of power had dropped to $9,209.01. I have not the corresponding figure for Port Huron in 1929 before me, but if the rates have not been cut there, the directors are paying nearly 60 per cent. more for the power on one side of the river than is paid on the opposite shore.

Of course there may be local modifying factors in the comparisons. The Detroit Edison Company, it will be conceded, pays 5.4 per cent. of its income in taxes, and the cost of developing power in Port Huron and of bringing it fifty-five miles from its generating plants in Detroit may be greater than that of producing it by water at Niagara and carrying it over 200 miles to Sarnia. The purpose of this article is narrative rather than controversial, but several other instances might be cited where United States industries are paying 60 per. cent. more for power than Ontario industries in a corresponding geographical location.

To reveal graphically the last year's operations of the local Hydro at Sarnia, let us imagine an annual meeting of the commission. We will assume that the year's income from all sources (three classes of consumers) is in a heap on the table. To simplify figures, let us suppose the money to be in the form of ordinary thousand-dollar bills, amounting to the sum of $330,000.00 which the utility has collected during the year. There are several claimants for a share of the money. We will deal with the most important first, and ask him to explain his claim.

"I represent the Hydro-Electric Commission of Ontario", says the applicant, "We are the people who developed and transmitted to you the current you sold. We are the trustees for this purpose on behalf of all the municipalities, half a thousand in all. We have billed your power to your city at cost. Hand me the money for 1930."

He is given a wad of 206 bills.

The local manager rises. "Give me the money for running expenses," he says, "including salaries, wages and ordinary maintenance." He is given forty-two bills from the diminishing pile.

A lineman in overalls rises. "Don't forget that this distributing system can't last forever", he says. "It is well maintained, but each year some money should be put into the box marked 'Reserve against Depreciation'."

We satisfy him by placing fifteen bills in the box.

A banker rises next. "I represent the people who advanced this city the money to buy out the utility. You agreed to pay interest and to reduce the principal by a cash payment every year"

He takes thirteen bills for interest, and seventeen to apply on reducing the principal.

All the bills and disbursements have now been met, but there are still thirty-seven of the big bills on the table. This is the surplus, caused by better business since the beginning of the year. It will be applied to plant betterment.

Let us complete our picture by asking the representative of headquarters what disposition is to be made of Sarnia's contribution of $206,000 toward main operations.

"Six per cent. will be put aside for depreciation reserve", he states. "Seven per cent. will be set aside to be held as a reserve against obsolescence and for contingencies. Ten per cent. will go directly to pay off some of the debt on our works, or will be reserved for that purpose. Twenty-four per cent. will take care of our running expenses. Three per cent will cover certain miscellanies, and the remaining 50 per cent. will go for interest. This ratio applies to all the money that comes into our hands", he adds, "in payment for current delivered, 'Wholesale'."

"Do you tell us seriously", we ask, "that interest eats up half the money you collect from the municipalities for power?"

"Yes, and we are applying one dollar out of every ten we receive to pay off principal and reduce this interest. Let me read the official statement on this:

"Ontario consumers can look forward to the time when the present plant will be clear of encumbrance and they will be relieved of paying interest and sinking fund thereon, which together amount to 60 per cent. of our total expense for generating and transmitting power. Concurrently, the municipalities in their local fields are carrying out the same sound financial procedure with respect to their local systems".

We pause to grasp the significance of this. We perceive that if the present thrifty policy is continued, of retiring principal borrowings out of the proceeds of current sold to the public ostensibly at cost, then the

great province will be able to make even further reductions in prices that already are low enough to challenge the attention of the world. Since these low prices will be immediately available to every industry, we can see grounds for a prediction already heard in Ontario, i.e., that the local branch plants of United States parentage already in Ontario, and new ones which are steadily arriving, may in the future becomes the logical seat of manufacture for foreign-export orders received at the office of the parent plant. There is already evidence of this, as Dr. Julius Klein, Assistant Secretary of Commerce, will testify. In an article in *The Saturday Evening Post* on "Migrating Machinery", he specifically mentions the fact that big United States industries are finding it advantageous to fill their export orders to South America and other countries from plants on the Canadian side of the border. "This is a phase," writes Dr. Klein, "which is frankly disconcerting."

These matters, however, are beyond the scope of our present article. It is a sufficient indication of the progress of Hydro finance merely to recall that the Sarnia plant collected in the past year from its consumers $330,000.00 and tucked away, including all reserves, $78,000.00 of it as a sort of rainy-day fund, to achieve fuller financial liberty and to clear the way for lower prices later on. And all this was accomplished at the surprisingly low consumers' prices previously cited.

"but—but—" objects a friend who happens to be a staunch upholder of individualism and giant private-power mergers, "you have failed to show that your sample town is typical, in regard to prices. Does it in fact represent a fair average?"

No, we have been cunning in selecting our sample. Middletown, as our friend suggests, is not in the middle. Sarnia is, of course, up to date and thriving, but its power cost of $31.24 and its domestic cost of two cents cannot at all be described as fairly typical of the group of sister cities of the Niagara system to which it belongs. Sarnia was not an early member of the family. Her border advantage is her electrical disadvantage. Sarnia was selected because, in defending Ontario Hydro, a writer can afford to be generous—and Sarnia happens temporarily to be not the lowest priced, but one of the highest, of the group.—*The New Republic.*

O.M.E.A. and A.M.E.U. Convention at Bigwin Inn, Lake of Bays June 23, 24 and 25, 1932

Human Engineering in Industry

(A Business Philosophy)

By A. W. Swan, B.A.Sc., Leicester, England

THE industrial executive is distinguished from the individualist research worker by the fact that he is far more concerned with men than with things. His selection and use of human material has more to do with his success or failure than any other factor, and the study of how to deal with men above, around, and below him, is therefore of vital importance to him.

THE CONSERVATION OF BUSINESS ENERGY

In constructing an organization of men, be it large or small, the successful executive adopts the principle that to conserve men's time and energy is as important as to conserve material; and he includes his own time and energy in this consideration. In laying plans to conserve energy there is a difference between working and being busy; the executive who so plans and distributes his work that he has a clear desk and time each day to think and plan may not be nearly so busy as the executive who has a mountain of papers on his desk and prides himself on his long day and evening hours—but there is little doubt which accomplishes most. A Managing Director cannot also be his Works Manager, Sales Manager and Chief Accountant, any more than a Works Manager can also be his Production Engineer, Assembly Superintendent and Foundry Superintendent. The executive of whatever rank is therefore driven by the principle of the conservation of business energy to build his staff on the principle that work is distributed by each chief to competent subordinates, to whom genuine responsibility with defined limits is given. The work retained by each executive will be far better done than if it had to compete with detail work which should have been done by juniors.

A certain American industrial organization which has adopted this principle whole-heartedly, tests results in a rather fearsome way. A department head is apt to find himself called into the president's office, and told to take a holiday forthwith. If he returns from the holiday to find that only that work which is his immediate concern has halted, and that his department has had no calamities, well and good; but if he has been arrogating too much to himself, with the result that his department has been brought to a standstill, he is dismissed. The test is not recommended, but the principle is sound.

It might be thought that the system of de-centralizing work would make for looseness of control and lack of discipline; but the reverse is the case. Where duties are loosely defined and there is overlapping between executive and subordinate, and between department and department, there is no definite check on any specific activity. Where, however, work is definitely assigned,

and a system of verbal and written reports is in force, the chief is fully aware at all times of all that goes on within his jurisdiction, and discipline is easy to maintain. There is all the difference in the world between the vague and fussy control of the executive who cannot leave detail alone, and who is therefore unable to see the wood for the trees, and the firm control of the strong executive who is able to distribute detail work and to trust that it is being done, but who has it distinctly understood that the trust is provisional, depending for results on whether it is continued.

Difficulties of De-centralizing Work

Almost everyone will pay lip-service to the principle of distribution of work outlined above; but even the most willing find it difficult to carry out in practice; and the more conscientious they are, the more difficult they may find it. It requires considerable strength of mind and resolution not to worry over what is happening out of one's own immediate ken, and to refrain from meddling or even reminding. There is a further difficulty; responsibility to be genuine must not only include action, within carefully defined limits, but the right of decision. A chief is not really deputing work when every time he differs from his junior he compels the junior to accept his decision. With a reasonable use of the executive veto, the executive must be prepared to back his choice of man rather than his own opinion at any given moment; the junior may well be more expert than he on specific matters.

This very bold policy, and it is bold, pre-supposes extremely careful selection of the human material in the first place, clearly understood limits of responsibility, and an understanding that these limits are to be revised upwards or downwards according to results shown.

Overlapping is, however, not only destructive of efficiency when it is downwards by executive meddling with his subordinate's duties; it must also be avoided upwards by the junior overstepping his limits, and sideways by department against department. Responsibilities must there be clearly understood by all interlocking units in an organization.

The number of subordinates per chief varies according to circumstances; the rule being that there must never be more than can maintain adequate personal contact. This contact may either be through daily discussion; or as in the case of a Sales Manager with scattered staff, through written memoranda and reports, supplemented by verbal discussion at longer but fixed intervals. Where the claims on an executive's time by his own personal work and contact with superiors and those external to his firm are considerable, as in the case of a managing director, the number of subordinates directly responsible may be as small as five; whereas the shop foreman may be able to deal adequately with twenty men. In any case, whether the number be large or small, the responsibility must at all times be direct, and not through the go-between who has no powers of his own.

The plan outlined above of constructing an organization on the

principle of de-centralizing work, is not merely theoretical; it is adopted and used; and an actual conversation bears this out in a rather amusing but graphic fashion. "Build his staff on the principle that work is distributed to competent subordinates, eh! Why, I do that; I have a good manager in each department, and while I wouldn't like to go away for six months, I could go away for a month, and not worry. Why, only this morning a friend of mine in the L.S.D. group rang me up and said, 'Look here, Jack, what would happen to your business if you were run over by a 'bus?' 'Nothing', I said, 'it would go on the same as usual; it would miss the motive power after a while, no doubt, but it wouldn't stop at all.' 'Good', said he, 'We have quite an amount of money invested with you, and I was just wondering how your show would get along if you popped off suddenly.' "

Starting and Running an Organization

Having built his organization, the executive is faced with the problem of starting it and keeping it running. Just as in the work of constructing the organization his success will depend largely on whether he selects the right men for the right jobs, so in running the organization his success will depend almost entirely on the extent to which he succeeds in arousing the inward energies of these individuals, and keeping them aroused. For it is plain that no executive, however abounding in energy and enthusiasm he may be, can apply his own force to the work done by his staff; and the man who tries to do this fails. He must find forces within the individual members of his staff, and find means to keep those forces fully energised.

There are in effect, two primal urges which the executive can utilize, both powerful, both effective as producers of work, but inconsistent with each other—fear and ambition. Fear is undoubtedly a powerful motive, but it has the disadvantage from the standpoint of efficiency that it will merely maintain that level of work which will prevent censure or dismissal; whereas ambition builds upon itself and knows few limits. The efficient executive, therefore, decides to use ambition as the force which will bring him the best results; and he decides, therefore, to lead rather than to drive. In this decision he will be considerably helped by the fact that modern Anglo-Saxon character is so constituted that nine men can be easily led to the one man who is so stupid that he must be driven; and there is no place for the tenth in present-day industrial organization.

The Use of Ambition as a Driving Force

It is strange how ambition has been neglected in what may be termed the middle ranks of industrial life. Piece-work and bonus systems of payment are commonly used in the shops and mills to increase production; and withal, the more money the worker earns the better it is for his employer. In the higher ranks, among superintendents, managers and heads of departments, the same principles are employed in high salaries and ample opportunities for advance-

ment. But in the massed ranks of the black-coated clerical and technical workers ambition is used as an urge, if at all, in a very half-hearted manner. The accusation is sometimes levelled at certain Trade Unions that they try to restrict the earnings of skilled workers and thus to reduce all to the level of the least skilled instead of raising to the level of the most skilled. Whatever truth there may be in this accusation, many employers cannot escape a similar accusation in regard to their clerical and technical staffs. Standard rates, with standard annual increases whatever the relative merits of the individuals concerned, have a deadening effect; particularly if a, "Be thankful you have a job", attitude is encountered on the part of the employer, as is still sometimes the case. Such employers do not realize that they are their own worst enemies, that "something for nothing" is just as much a will o' the wisp in regard to men as it is for goods, and that in the long run they receive back in value of work precisely that for which they pay.

While ambition is the main force upon which the successful executive relies in his dealings with his subordinates, he recognizes that just as the engineer studies his materials and treats brittle cast-iron differently from elastic low-carbon steel, so must he as a human engineer study his human materials and act according to the results of his observations. Men vary greatly, for instance, in regard to ambition, some are keen for promotion, develop under responsibility, and are the material from which executives of the highest ranks are made. Others, equally trustworthy, equally hardworking, fear responsibility and are more concerned with security of position. The executive sees to it, therefore, that each member of his staff has dangled before him, as it were, the particular size of carrot which he desires, fitting ambition to the individual. In doing so he must not forget himself, and the soundest way of firing his own ambitions is to have an understudy. One of the pioneers of present-day industrial management used to attribute his success in life to the fact that throughout his career he invariably saw to it that he had an understudy; when the latter was ready to step into his shoes he himself was ready for a more important post.

Praise and Blame

Ambition, however, may be for smaller rewards than increased salary or higher position; and it is the executive who constantly remembers this important fact who secures the best results. Praise, for instance, which adds nothing to working costs, is a valuable tool; and one is constantly surprised that it is used so sparingly. Ambition is, after all, very much like the force in a wound up clock spring; the clock must be wound up, ambition must be renewed; and while the major way of keeping ambition alive is through increase of pay or promotion, praise is a useful supplement and even substitute.

The use of praise as a stimulant to good work does not imply a sloppy sentimentality; the executive who is merely expansively genial is as inefficient as the executive who scolds. Ideas have to be conveyed and policies carried out, and in an imperfect world

this implies the necessity for criticism. But there are two points of view in regard to criticism, in keeping with the driving and leading policies outlined above; that criticism is necessary frequently to keep subordinates from being lazy or inefficient, and that it should be given as seldom as possible, and when given administered in such a way as to stimulate rather than diminish ambition.

Criticism may, in fact, be efficient or inefficient, depending on whether it achieves its object; and it calls for a careful technique, not always easy to remember when one is annoyed over a blunder or sin of omission. Criticism is efficient when it makes the culprit take his own steps to ensure that there are no further grounds for criticism, and all criticism must be measured against this standard.

If the purpose of criticism is to improve efficiency by stimulating ambition, it is clear that a scolding has the opposite effect. The internal satisfaction felt as one watches a victim squirm before well chosen words is dearly earned if the effect is to arouse indignation and to lower the sense of guilt. The executive, in fact, who hurts a subordinate's feelings commits a business blunder; and this applies not only to the sensitive highly trained technician, but to the workman, the typist and the clerk.

Even the best-tempered executive, however, has other difficulties to contend with when he criticises. It is, for instance, the easiest thing in the world to come to such strong convictions on the correctness of a particular course of action that any other course seems ridiculous and wrong; and one can on this righteous basis proceed to lecture a subordinate who has taken upon himself to differ. Nobody is especially picked out to be always right. Actually, it may be a matter of personal opinion, and while it may be necessary to enforce one's views, the plane of the discussion is altered if it is recognized that the decision is on this basis and it is not a case of right versus wrong. A more fundamental difficulty is to make the criticism 100 per cent. efficient in stimulating to better work; it is not sufficient for a criticism to steer clear of the destructive, nor even is it good enough to be mildly constructive; it must have a galvanizing force. To give the impression that there is an irretrievable black mark, for instance, kills ambition; on the contrary, one should be surprised at having to criticize, and confidently expect that no further criticism will be necessary.

Schoolmasters achieve surprising results from backward boys by emphasizing the good work that they do, and minimising the bad; and the practical psychology of the classroom is by no means to be despised by the executive who has to deal with grown-up boys governed by much the same laws of conduct. The executive who has it known that he normally expects good work and is surprised by bad work will secure better results than the executive who is difficult to please. It is good policy to allow the subordinate to work out his own improved methods, and to make good his sins of omission and commission with the minimum of supervision and reminding; his

improvement must come from within himself.

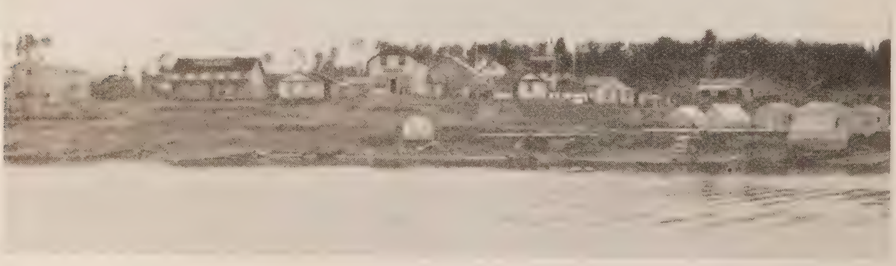
The Executive and his Superiors

While there is a fairly close analogy between the engineer and the industrial executive, there is the difference that the executive is himself a part of the machine; even the managing director has to consider his board of directors. It is not therefore, sufficient merely to know how to build and run one's own organization, but to know how to deal with colleagues and superiors. The principles on which actions are based in this connection are, however, very similar to those already laid down. It is, for instance, just as sound a principle never to irritate a superior or colleague in argument as it is never to hurt a subordinate's feelings, and for precisely the same reason, that it is inefficient. It is not only much more pleasant, but much more effective to study the point of view of the superior or colleague concerned, and present the case as far as possible from that point of view. Even if one is burning under a sense of injustice, it does no harm to assume that the other party to the dispute has at least acted in good faith; even the heavy-handed autocrat is usually unaware that he is so. The process is in fact that of selling and requires the same technique, including observance of the fundamental principles that a sale is never made to an angry customer, and that, "The customer is always right". If a superior requires masses of figures and lengthy reports, it is good policy to provide the same; whereas if he prides himself on being a man of few words requiring essentials only, let talks and reports be brief. It is, too, a good principle, when a disturbance seems inevitable, to bear in mind that it requires more brains to gain one's ends peacefully than by having a nice, satisfying quarrel. As in the case of the equally satisfying browbeating to a subordinate the satisfaction is dearly earned if it loses the objects desired. In fact, human engineering is as important in this section of one's activities as in dealing with subordinates.

The Last Phase

Finally, of course, one comes to still another phase. If the study of human characteristics, reactions and behaviour are important for the industrial executive, he must complete the study by dealing with himself. But that is another story.

University of Toronto Monthly.



Association of Municipal Electrical Utilities

Minutes of Executive Committee Meeting

A meeting of the Executive Committee of the Association of Municipal Electrical Utilities was held at the office of the Hydro-Electric Power Commission of Ontario on Tuesday, March 29th, 1932. The meeting was called to order at 2.00 p.m. by the President, Mr. C. E. Schwenger. Other members of the Executive Committee present were Messrs. J. E. Skidmore, R. S. King, E. V. Buchanan, O. H. Scott, M. W. Rogers, T. W. Brackinreid, J. W. Peart, W. R. Catton, T. J. Hannigan, H. T. Macdonald and S. R. A. Clement.

This meeting was called for the purpose of arranging for the Summer Convention of the Association to be held at Bigwin Inn on June 23rd, 24th and 25th, 1932, as also of transacting any other business to be brought up.

It was moved by Mr. E. V. Buchanan and seconded by Mr. T. W. Brackinreid "THAT the Minutes of the Convention of January 27th and 28th, 1932, and of the Executive Committee meeting of January 27th, 1932, as published in THE BULLETIN, be taken as read and adopted." —*Carried.*

Regarding the resolution carried at the January Convention, asking that the Rates Committee investigate and report on the use of prepayment meters, Mr. W. R. Catton, Chairman of that Committee, advised that the Committee would meet at a later date.

The resolution from the Committee on Accounting and Office Administration referred to this meeting by the Executive Committee meeting of January 27th, was considered. This resolution suggested changing the by-laws to permit the formation of sections of the Association with officers elected to fit in with such sections.

It was moved by Mr. O. H. Scott and seconded by Mr. E. V. Buchanan "THAT the resolution from the Committee on Accounting and Office Administration be referred to a Committee consisting of Mr. R. L. Dobbin, the President, the Past President, the Secretary and the Treasurer."—*Carried.*

The application of Grand and Toy, Limited, for commercial membership in the Association was presented.

It was moved by Mr. E. V. Buchanan and seconded by Mr. J. W. Peart: "THAT Grand and Toy, Limited, be declared elected a commercial member of this Association." —*Carried.*

Opening the discussion of plans for the Summer Convention, Mr. T. J. Hannigan advised that the Ontario Municipal Electrical Association would undertake to obtain speakers for the Convention luncheons and dinner.

Mr. T. W. Brackinreid, Chairman Convention Committee reported that a meeting had been held and committees appointed to take charge of transportation, hotel reservations, entertainment, sports and prizes,

and asked for $225.00 for prizes and entertainment. Mr. Brackinreid moved the adoption of his report, which was seconded by Mr. O. H. Scott.

Mr. E. V. Buchanan moved and Mr. J. W. Peart seconded an amendment: "THAT the Convention Committee be granted $100.00 for entertainment and that prizes be eliminated."—*Carried.*

Mr. E. V. Buchanan, Chairman Papers Committee reported a meeting of that Committee, and that it is proposed to obtain five papers, one to be given on the afternoon of Thursday, June 23rd, two on the afternoon of Friday, June 24th, and two on Saturday morning, June 25th. He reported having eight suggestions from which to choose. Mr. Buchanan moved the adoption of his report, which on being seconded by Mr. T. W. Brackinreid was *Carried.*

The Secretary asked for advice regarding the purchase of badges for the Convention, showing samples of various designs and giving prices. It was moved by Mr. W. R. Catton and seconded by Mr. E. V. Buchanan: "THAT badges be dispensed with for the Convention and that instead printed paper tags be used."—*Carried.*

The Secretary reported as to membership for this year advising that thirteen new utilities had sent in dues, that three new commercial memberships had been paid, and that renewals of membership were coming in better than last year. He was instructed to give each District Director a list of the Utilities in arrears in his district, so that he could communicate with them.

The Treasurer reported as to the finances of the Association, which showed that the economies ordered in the preceding items covering Convention arrangements are necessary.

The policy of issuing complimentary tickets to Convention dinners and luncheons was discussed and it was moved by Mr. J. W. Peart and seconded by Mr. O. H. Scott, "THAT in future the matter of issuance of complimentary tickets for Convention meals be at the discretion of the President and the Secretary, and that complimentary tickets handed the Ontario Municipal Electric Association for their use be marked and those used billed to them direct."—*Carried.*

Reference was made to the difficulty experienced by newspapers throughout Ontario in obtaining first-hand information for publication on Hydro matters. It was moved by Mr. O. H. Scott and seconded by Mr. E. V. Buchanan: "THAT we recommend to the Ontario Municipal Electric Association that news dispatches re Hydro, for use by the local newspapers be sent out through the Secretary of that Association to the Local Commissions."—*Carried.*

There being no further business the meeting then adjourned.

THE
BULLETIN
Published by
HYDRO-ELECTRIC POWER COMMISSION
of Ontario
190 University Ave. Toronto
Subscription Price $2.00 Per Year

North Yonge Auto-Transformer Station and Willowdale Distributing Station

By H. V. Armstrong, Assistant Engineer, Electrical Engineering Department, H.E.P.C. of Ont.

ON June 28th, 1931, the Commission placed in operation a combined auto-transformer station and a distributing station at Willowdale, the former for supplying power at 26,400 volts to the various municipalities north of this point to Lake Simcoe, a distance of approximately 42 miles and the latter for distributing power to part of the North York Township at 4,000 volts.

These two stations are located on property purchased by the Commission and situated on Norton Boulevard in the Willowdale District, approximately two miles north of the limits of the City of Toronto. On this property is also a one-storey buff brick building 51 ft. long x 35 ft. wide constructed by the Toronto Transportation Commission for housing the railway equipment for the North Yonge radial as well as the 4 kv. equipment for the Willowdale Distributing Station.

High Voltage Structure and Equipment

The outdoor structure supplied by the Canadian Bridge Co., and erected by the Commission's Construction Department is of fabricated steel 79 ft. long by 24 ft. wide divided into five double bays, the first for the two 13,200 volt incoming lines, the next two for the distributing station outdoor equipment and the last two for the auto-transformer station outdoor equipment. Each incoming line is provided with lightning arresters and a gang-operated air break switch and then bussed together on the structure with another gang-operated air break switch placed in this bus between the two incoming lines for use as a bus sectionalizing switch. Provision is made in this bay for future incoming line oil breakers and necessary switching equipment. These lines are fed from the Glengrove sub-station of the Toronto Hydro-Electric System

CONTENTS

Vol. XIX **No. 5**

May, 1932

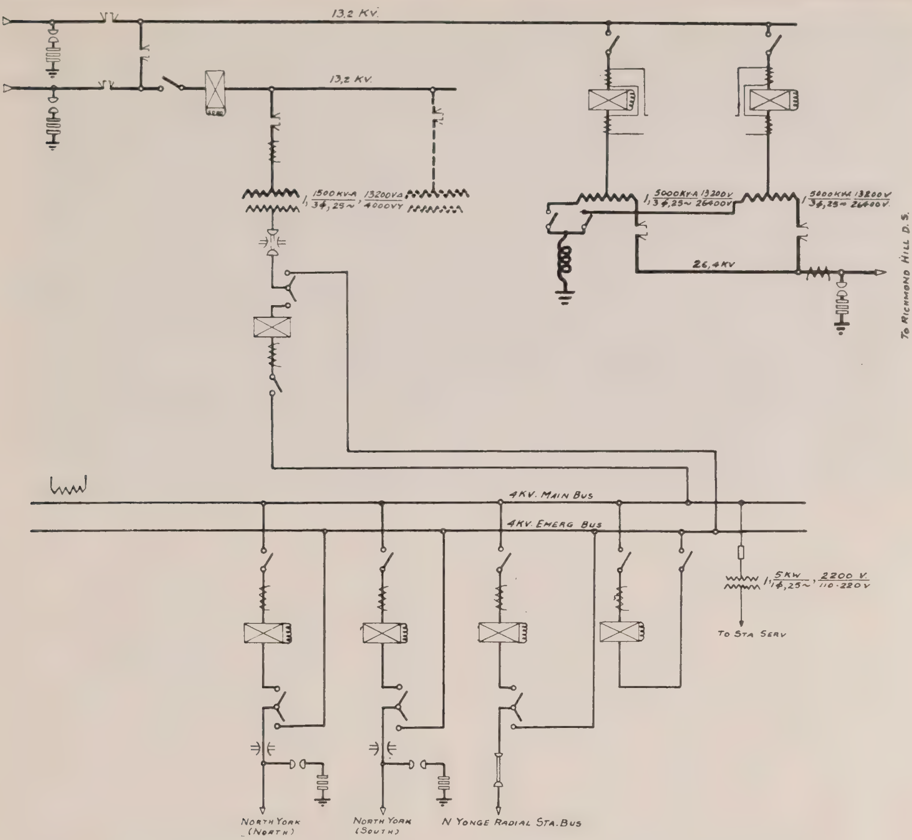
where adequate protection is provided. The next two bays are used for the distributing station in one of which at present is installed a 1,500 kv-a., 3 phase, 25 cycle transformer. This transformer is connected through a set of gang-operated disconnecting switches to the 13,200 volt bus strained between these two bays, this bus in turn being connected to the line bus through an oil breaker. Outdoor type current transformers are installed in the 13,200 volt taps to the transformers for supplying current to relays which trip this bus oil breaker.

The transformer manufactured by the Canadian General Electric Co., is rated at 1,500 kv-a., 3 phase, 25 cycle, 26,400–13,200/2,300–4,000 volt, oil-insulated, self-cooled, outdoor type. The oil breaker is a 600 ampere, 26,400 volt, type CH2, manufactured by the Canadian Westinghouse Company, who also supplied the 100/5 ampere, type MB, outdoor type, current transformers.

The remaining two bays are used for the auto-transformer station in each of which is installed a 5,000 kv-a., 3 phase, auto-transformer. The 13,200 volt side of each transformer is connected to the 13,200 volt bus through an oil breaker having bushing type current transformers. The 26,400 volt side is connected to the 26,400 volt bus through gang-operated air break switches. On the end of this bus are installed three 200/5 ampere, air-insulated current transformers, also pellet type lightning arresters.

A single phase, 10 ohm, grounding reactor is installed between the two auto-transformer oil breakers and connected to the neutral of each transformer through disconnecting switches.

The two auto-transformers manufactured by the English Electric Co., are each 5,000 kv-a., 3 phase, 25 cycle, oil-insulated, self-cooled, outdoor type units, 26,400 volt Y to 13,200 volt Y with three 5 per cent. under voltage and two 5 per cent. over voltage taps on the 13,200 volt windings. A tertiary winding of approximately 25 per cent. of the capacity of main windings is provided. Each transformer has no load hand-operated tap changer switch operated from the ground. The oil breakers are 600 ampere, 15,000 volt, type CH1, manufactured by the Canadian Westinghouse Company. The grounding reactor manufactured by the Canadian General Electric Co., is of the cast-in-concrete type and rated at 4,900 kv-a., 700 ampere, 7,000 volts, single phase, 25 cycle, 10 ohms with 8 and 6 ohm taps. The air-insulated current transformers and



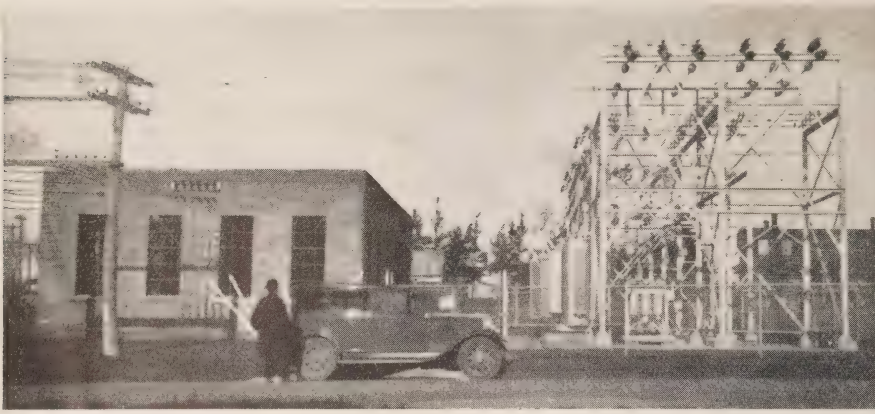
Wiring diagram, North Yonge Auto-Transformer Station and Willowdale Distributing Station.

gang-operated, air break switches were manufactured by the Commission's Production and Service Department. The pellet type lightning arresters are Canadian General Electric Co's., manufacture.

Low Voltage Equipment and Structure

Adjacent to the outdoor structure is the one-storey brick building, in the north part of which the Toronto Transportation Commission have installed two 500 kw., motor generator sets and necessary equipment for supplying direct current power to the North Yonge radial line. In the south section is located the distributing station switchboard and 4,000 volt switching equipment.

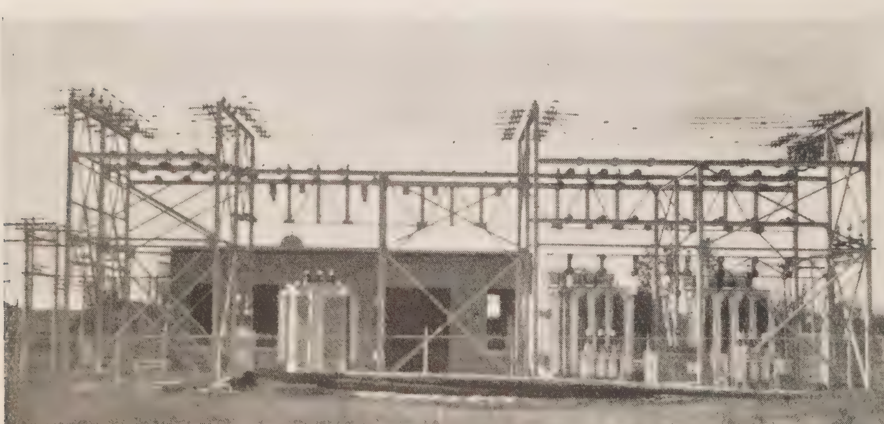
All the 4,000 volt apparatus is mounted on pipe structure at the rear of the switchboard with one passage between the switchboard and oil breakers and another between the oil breakers and south wall. Over the first passage is the main bus and over the other is the emergency bus, both made up of one 2 in. by ¼ in. bar. Provision is made for an ultimate installation of ten feeder equipments with the present installation of



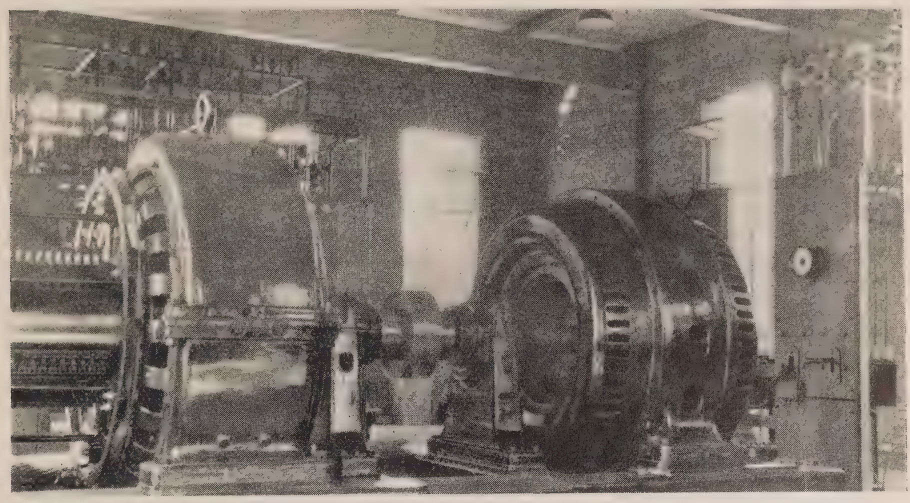
View looking north of North Yonge auto-transformer station and Willowdale distributing station.

five feeders consisting of one transformer, one railway, one bus tie and two outgoing. Each feeder is equipped with hand-operated, remote control oil breaker, current transformers and two sets of disconnecting switches. Connection between the low side of the transformer and oil breakers is made with three conductor, lead-covered cable laid under ground. All outgoing feeders leave the building overhead.

The switchboard consists of five ebony asbestos panels on which are mounted the handles for the remote control breakers, instruments and relays for controlling the high and low voltage breakers for the distributing station. At the left of this board is a single panel on which are mounted the ammeters and relays for the auto transformer station. In the south-east corner of the building is located the 24 volt battery.



View looking west showing steel structure and outdoor equipment.



Interior view showing Radial motor generator set and Willowdale distributing station 4 kv. equipment.

The panels, oil breakers, current and potential transformers, relays and bus supports were manufactured by the Canadian General Electric Co. The disconnecting switches were manufactured by the Commission's Production and Service Department. The battery was manufactured by the Monarch Battery Co.

All the installation work was done by the Commission's construction staff except the railway equipment which was installed by the Toronto Transportation Commission.

OPERATION

All oil breakers in the distributing station are closed by hand, but with the exception of the transformer low voltage breaker, are automatically tripped through the overload relays using the 24 volt battery as the tripping source.

As the taps on the auto transformers must not be changed under load and as the two 13,200 volt oil breakers are closed by hand, it was necessary for the convenience of operation to install a trip switch near each oil breaker. To make certain that the operator would not attempt to change the taps on the transformer while carrying load, this trip switch and the tap changer switch are each provided with a lock having a common key and is so arranged that the breaker must be tripped by the tripping switch before the key can be removed to unlock the tap changer switch handle.

The bushing type current transformers on the 13,200 volt oil breakers provide current for the ammeters and current balance relays while the air-insulated current transformers on the 26,400 volt feeder provide current for the overload and ground relays which give phase and ground protection to this feeder and ensures that it will not be tripped out due to faults in the 13.2 kv. system.

The installation of the grounding

reactor in the auto transformer station neutral was found necessary to reduce the ground current to a point where the residual backfeed would not interfere with the relaying at the T.H.E.S. Glengrove Station and Leaside Transformer Station.

METERING

As the distributing station serves part of North York Township, the total load is measured by Lincoln graphic recording and graphic r.kv-a. meters, and the power delivered to the railway is measured by a Lincoln graphic recording wattmeter and a Sangamo watt-hour meter.

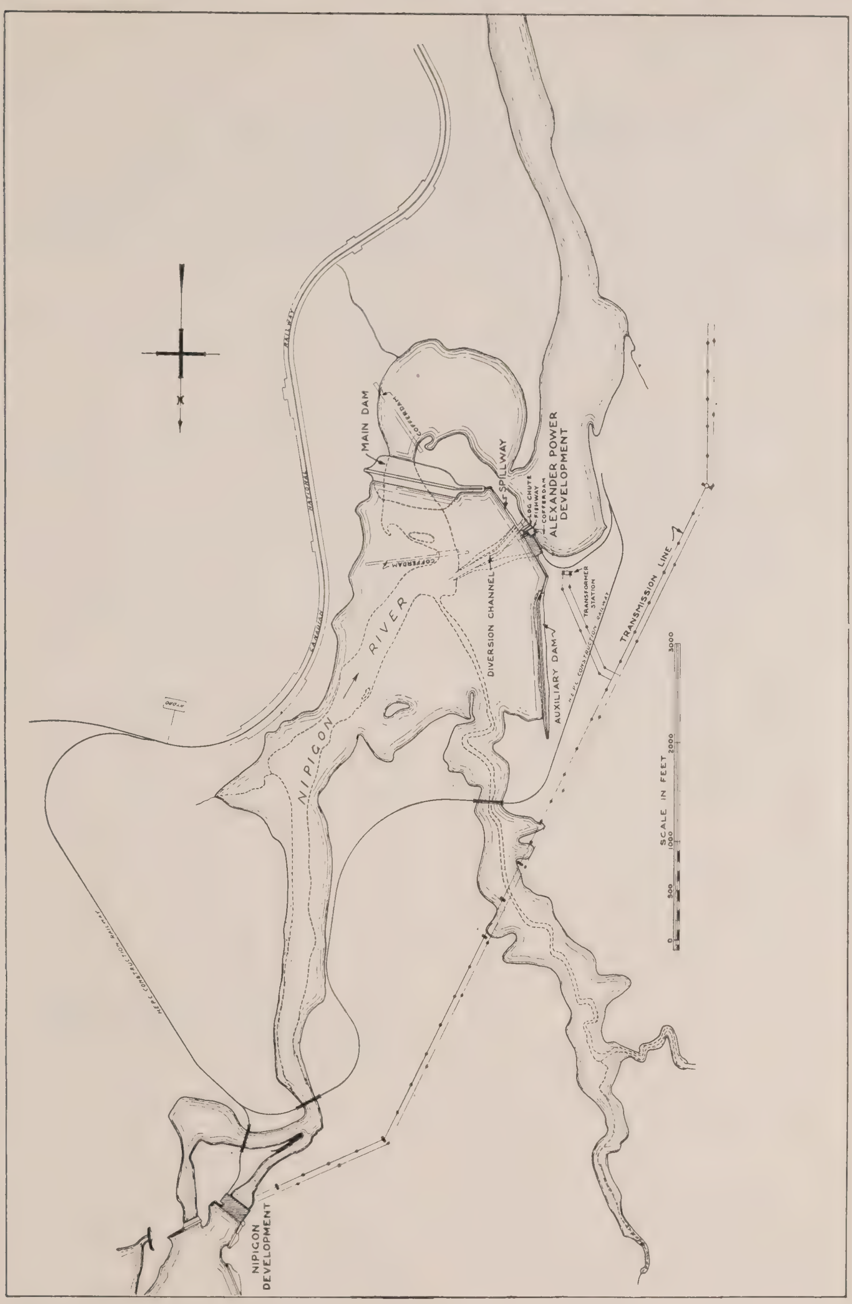
Some Features of the Alexander Power Development

By D. Forgan, Assistant Engineer, Construction Dept. H.E.P.C. of Ontario

IN October, 1930, the Alexander Power Development, the second on the Nipigon River, was put into service by the Hydro-Electric Power Commission of Ontario. This development has a capacity of 54,000 h.p., and along with the plant at Cameron Falls supplies power to the Commission's Thunder Bay System. THE BULLETINS of May and June, 1931, gave a description of this plant, referring more particularly to the engineering features. Reference was made to the general construction of the main dam which is of the hydraulic fill type, and of which few have so far been built in Canada. This article refers more particularly to the construction of the dam which was carried out by the Commission's Construction Department, while also touching briefly on some of the other work accomplished.

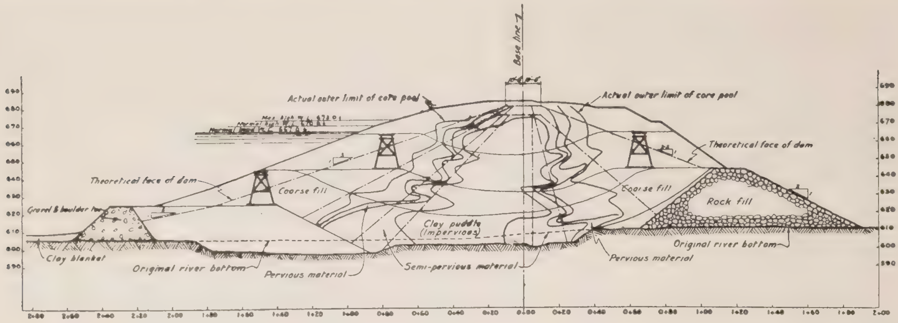
The power house is a pleasing structure of brick and concrete, located at Alexander Landing, the foot of the old "Long Portage" over which all canoes and supplies of voyagers northbound towards Lake Nipigon, had to be carried two miles to the head of Cameron Falls. Now due to the development of this section of the Nipigon River, a quiet lake stretches between these two points and a railway, instead of a rough portage, connects them.

The dam may be briefly described as essentially a clay core impervious to water, supported on each side by a fill of heavy gravel, rock and earth, of sufficient size and stability, and sealed to the ground below and at the ends, to hold back the artificial lake which provides water storage for the powerhouse. Usually, the main dam for a development is built in the original river channel and is of concrete or masonry. Such structures require a foundation of solid rock within economical reach, but at the Alexander site, although rock cliffs were visible on each side of the river, borings through the boulders and clay forming its bed showed that no solid



Plan showing location of the Alexander Power Development on the Nipigon River.

rock existed within a hundred feet of the surface. It was obviously impractical to excavate this depth for a concrete dam so the hydraulic fill type, to be built of materials obtainable locally, was adopted.



Typical Section of earth dam, Alexander Power Development.

In order to allow the dam to be placed in the old river bed, the whole flow of the stream had to be diverted. This was accomplished by digging a channel through the peninsula on which the powerhouse is situated and placing a temporary timber crib dam in the river above the dam site. This channel ended in a concrete sluiceway, which later formed the base of part of the spillway, in which heavy steel gates could be dropped when the dam was completed, to seal the canal, and divert the water through the powerhouse. This operation was successfully carried out on the day scheduled many months beforehand.

The earth dam was the biggest single structure involved in the construction of the development. When completed it appeared almost a part of the natural landscape, as if the hill on the east side of the river had projected into the valley and been trimmed to a level top and regular slopes. From the lowest point to the crest it is almost 100 feet in height. It is over a quarter of a mile long, and, including the clay seal upstream from its toe, contains some 750,000 cu. yd. of earth, clay and rock. This fill was dug from adjacent borrow pits, ten locomotives, many railway cars, and four excavating machines being required to place it in the short summer of five months available for the work.

The construction of a dam of this nature is carried out by the placing of the excavated earth in two long banks of fill on the upstream and downstream limits, from the inner faces of which the clay and fine materials are washed by streams of water at high pressure into the centre of the dam to form the impervious core. A pool of water therefore exists in this enclosure during the whole of the construction period. This pool may be 8 or 10 feet deep and below it is a liquid mass of mud which gradually becomes impervious. During the progress of construction, as the dam increases in height, this mass of liquid has to be carried up, still enclosed between the loose earth walls. The greatest care has to be taken to prevent the pool bursting out, for were this to happen not only would much of the fill be lost, but locomotives and trains would possibly be swept away or toppled into the core, probably never to be recovered. Loss of life also is probable under these conditions, but fortunately, on this job, no such losses occurred.

Statistics do not possess much

general appeal but a few figures may be given to indicate the amounts of material handled in the major items of the job. Over 400 acres of bush had to be cleared first to enable railways to be built, camps erected and work started on the various items comprising the development. To allow for food, supplies, men, and materials to be brought up and the excavation and other work carried out, three miles of permanent railway and more than eight miles of temporary railways were built, including two large bridges over the Nipigon River and one of its tributaries. Housing accommodation, involving the construction of a temporary village with electric light, water, telephone and sewage systems for 550 men had to be provided. It may be of interest to note that for the feeding of the working force alone over 1,500,000 lb. of food had to be handled, cooked and distributed. Civic government in this community was simplified by the centering of power in one individual who combined all executive offices from Mayor to Works Commissioner. Problems of administration were therefore solved as quickly as they arose. More than 1,175,000 cubic yards of material were excavated, of which 101,000 yards were solid rock. Almost 800,000 cubic yards of hydraulic and rock fill went into the construction of the hydraulic and earth fill dams, and 40,000 yards of concrete were placed in the powerhouse, spillways, and other structures. Much of this latter work had to be carried on through the winter, when temperatures were as low as 45 degrees below zero for days at a time. This meant that elaborate arrangements had to be made to protect the concrete from the effects of the cold, so steam heat had to be lavishly provided in all concrete forms and in mixing plants. Over 3,400 tons of steel were moved into place in the form of turbines, electrical equipment, cranes and other details, and 450,000 bricks or their equivalent went into the building of the superstructure. Permanent buildings were provided for the operating staff of the station.

Convention Programme

The programme for the Summer Convention of the Association of Municipal Electrical Utilities to be held jointly with the Ontario Municipal Electrical Association at Bigwin Inn, Lake of Bays, Muskoka, on June 23, 24 and 25 will be as follows:

THURSDAY, JUNE 23rd

Morning:

Registration. The register will be open during the boat trip from Huntsville to Bigwin Inn and at the Hotel after the arrival of the boat.

Afternoon:

2.30 o'clock—A.M.E.U. Convention Session.

Reports.

Paper—"Development of Fuse Cutouts," by R. E. Jones, Assistant Engineer, Distribution Section, Electrical Engineering Dept., H.E.P.C. of Ontario.

4.00 o'clock — O. M. E. A. and A. M. E. U. Joint Session.

Evening:

9.00 o'clock—Dancing.

FRIDAY, JUNE 24th

Morning:

Sports.

Bigwin Trophy Golf Contest.

Afternoon:

12.30 o'clock—Convention Luncheon.

Address—

2.30 o'clock—A.M.E.U. Convention Session.

Paper — "Surge Absorbers," by G. A. Brace, Sales Manager, Ferranti Electric Limited, Toronto.

Paper—"The Importance of Record Control to Executive Management," by Henry J. Johnson, Remington Rand, Incorporated, Buffalo, N.Y.

Evening:

6.30 o'clock—Convention Dinner.

9.00 o'clock—Moving Pictures and Dancing.

SATURDAY, JUNE 25th

Morning:

9.30 o'clock — A.M.E U. Convention Session.

Paper—"Load Building Possibilities with Electric Heating Devices," by J. S. Keenan, Assistant to the Manager, General Merchandising Dept., Canadian General Electric Company, Limited, Toronto.

Paper—"Applications of the Photronic Cell," by M. B. Hastings, Vice-President, Powerlite Devices, Limited Toronto.

INFORMATION FOR DELEGATES

The hotel rate will be $7.50 per day per person, American plan, with two in a room, and no extra charge for the Convention dinner.

Railway transportation, $8.35 from Toronto to Bigwin Inn and return. Berths, $2.50 and $2.00, plus tax.

Special cars for Huntsville will leave Toronto late on the evening of Wednesday, June 22nd to meet the boat to Bigwin Inn on the next morning.

Covered parking, 50 cents per day.

Open air parking, free.

Ferry charge, 25 cents return trip.

Golf, Tennis and Bowling, free.

Special entertainment will be provided for the ladies.

Transformer Mounting Plates

By R. E. Jones, Assistant Engineer, Distribution Section, Electrical Engineering Dept., H.E.P.C. of Ont.

A NEW method of mounting distribution transformers is now available. The use of hangers and crossarms are eliminated and instead a pair of similar mounting plates is bolted to the hanger brackets on the case. These in turn are attached to the pole by means of two through bolts. The plates are so designed that the cutting of the grain in the poles is eliminated, a decided advantage where treated poles are used.

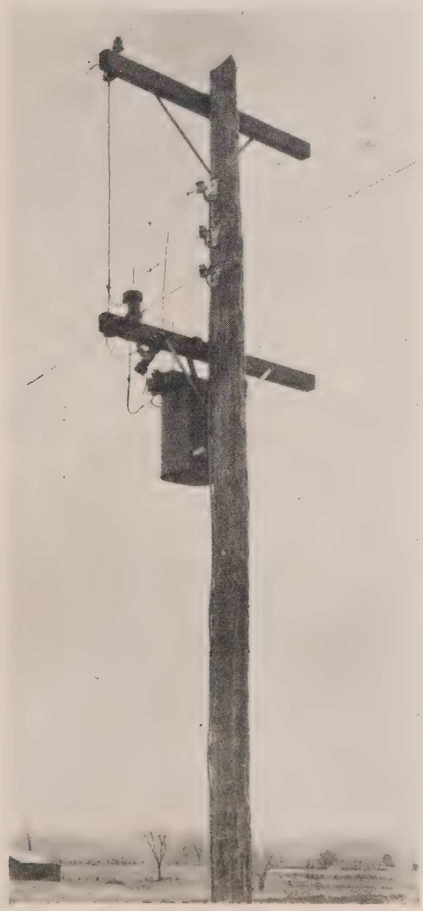


Fig. 1—Transformer mounted on crossarm.

Fig. 2.—Transformer mounted with plates.

An interchangeable extension bracket is bolted to either side of the upper plate to carry the arrester and the primary drop wire from the upper crossarm.

If it is desired to mount the cutout adjacent to the transformer case the arrester is placed on one side of the

bracket and the cutout on the other. The bracket will allow of the use of the various types of arrester and cut-out commonly used in Ontario. However the recommended practice is the mounting of the cutout on the line arm, using a type which can be operated with a stick. This allows safer operation as when the cutout is open, all wires below the line arm are dead.

The placing of the arrester on the transformer side of the fuse allows the line to be cleared in case of arrester failure. Experience has shown that it will not cause extra blowing of fuses in lightning storms.

These fittings permit the transformer to be wired on the ground or in the shop. In the field two bolts are placed in the pole, the transformer is hoisted to position, the primary, secondary and ground leads are connected and the job is done.

There is a considerable saving in material alone due to the elimination of crossarms, braces and hangers and the appearance of the pole is improved.

Figure 1 shows a transformer mounted on crossarms. Figure 2 shows the same transformer mounted with plates. Figure 3 is of the transformer wired on the ground ready to raise to position.

This arrangement was developed by engineers of the Central Hudson Gas & Electric Company of Poughkeepsie and was redesigned by the Distribution Section of the Electrical Engineering Department working with local manufacturers. Transformer makers are now prepared to supply all sizes up to 25 kv-a. with one size of hanger bolt (5/8 in.) so as to permit the use of these plates.

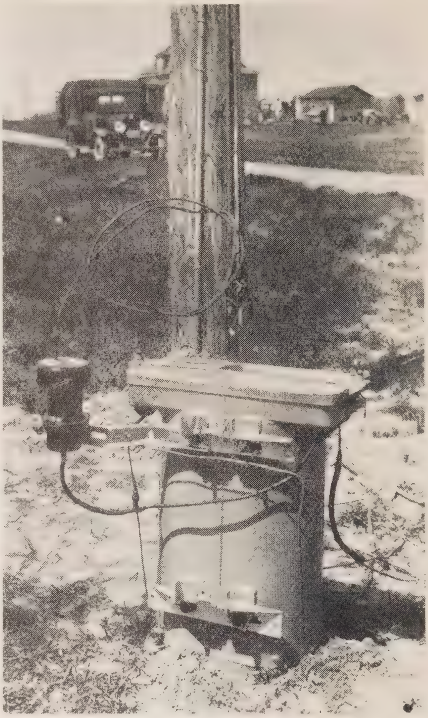


Fig. 3—Transformer wired ready to raise to position.

Hydraulic Features of Power Plant Design Contributed by Canada in 1931

By T. H. Hogg, D.E., Chief Hydraulic Engineer, H.E.P.C. of Ont.

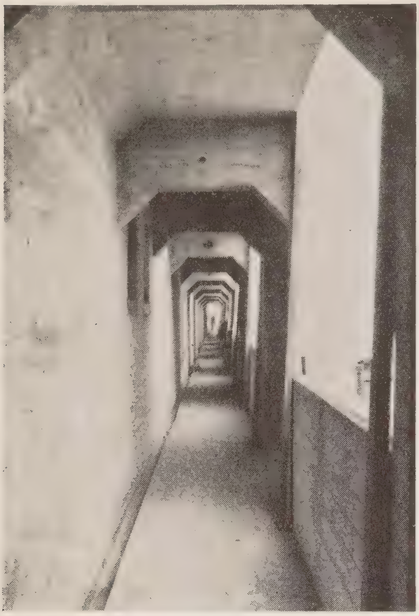
IN any review undertaking to outline new developments in the design of hydro-electric power plants in Canada during a given period, it is difficult to avoid repetition of previous practice. Endeavor will be made, however, to outline the tendencies towards the adoption of newer features which, in themselves, may not have been entirely developed during the past year, but which have been given greater consideration in the design of plants already under construction.

One of the most notable features in connection with the hydro-electric power industry in Canada during the past year is the fact that the total additional capacity placed in operation was considerably in excess of that for the years 1929 and 1930, during which 377,930 horsepower and 397,840 horsepower, respectively, were installed. The increase to 545,000 horsepower for 1931 in the face of the worst depression in history is a feature worthy of note and one that speaks highly for the stability of the industry. The total installed capacity at the end of 1931 was some 6,666,000 horsepower, as reported by the Dominion Water Power and Hydrometric Bureau of the Department of the Interior.

Among the technical features deserving of special mention may be cited the increased application of out-door type electrical equipment and the elimination of expensive superstructures for headworks.

Canadian power plants are generally subjected to severe weather and

Headworks deck of Alexander power development, Nipigon River, Ont., showing housing for gate hoists.



Alexander power development—Passageway through headworks housing (see illustration previous page); back wall of powerhouse on left showing warm air inlets and headgate hoists in bays on right.

ice conditions. Experience has shown, however, that headworks do not necessarily have to be closed in and heated to allow the water to flow freely into the conduits. At a number of the more recently constructed plants, only small housings are provided over the headgate hoisting equipment. Racks and stop-log gates are handled by means of out-door cranes and no special difficulties have been encountered as a result of the adoption of this type of construction. On the other hand, considerable saving has been effected by the elimination of expensive superstructures.

Marked progress has been noticeable in headgate hoisting mechanisms. Among the most important features in this connection may be mentioned the use of solenoid control for the operation of the main brake, enabling control of this feature to be extended to the control room, where the pressing of a button will automatically release the brake, allowing the headgate of any unit to close automatically. Considerable success is understood to have accompanied the installation of an air fan resistance as a governor to control the speed of lowering headgates.

The capacity of units installed is showing a steady tendency towards larger sizes, with noticeable increases in flow through the individual units of low head plants. This involves much larger intake and scroll case structures, with accompanying design problems, particularly in the matter of concrete reinforcing. The reinforcing in the scroll case section of the Beauharnois plant, which is to operate under a head of 83 feet, was simplified by making the section circular and anchoring the individual bars to the speed ring sections. These scroll cases are the largest constructed of reinforced concrete in this country. In the Abitibi Canyon plant we have, on the other hand, an example of the highest head steel plate casing in the Dominion, for plants of like magnitude. The operating head on this plant is 237 feet. At Chats Falls, where the operating head is 53 feet, concrete was used throughout, the scroll cases being designed in the conventional semi-rectangular section.

Elbow Type Draft Tube Preferred

In the matter of draft tubes, there

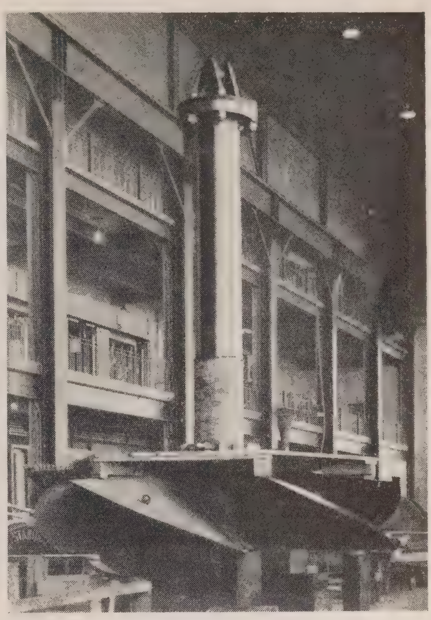
is a decided tendency to adopt the elbow type of draft tube in preference to other types, considerable improvement having been effected in the design, through which increased efficiencies at full and part loads have been made possible. These conditions, coupled with the lower cost and simplicity of construction, are adding to the favorable aspects of this type of construction. At one plant, in which elbow type draft tubes have been used, the maximum efficiency of the units obtained on test was 92.8 per cent., a figure that may be considered as highly satisfactory.

For Higher Efficiencies

The major power developments are, for the most part, connected to large generating and distributing systems and as a result the individual units in the system may be operated at the point of maximum efficiency whenever required, it seldom being necessary to operate any unit at other than its most efficient gate opening. This condition is conducive to the installation of the more economical propeller type runners, with an accompanying saving in generator costs by virtue of the higher speeds obtainable. Where low head plants are not thus favorably tied in with other generating stations, the advantages and economies of high speeds may be obtained by the adoption of the movable blade Kaplan type runners, as well as by runners with manually adjustable blades, in which high efficiencies are maintained throughout a wide range of head and load conditions.

Heating Elements

In the installation of headgates, provision is usually made for heaters adjacent to the checks, but the necessity for such provision is subject to serious question as it is seldom found necessary to provide heat under actual operating conditions. In the case of sluice gates, however, where more severe exposure is encountered, heaters are required not only for the gate checks, but within the body of the gate itself. Considerable advancement has been made in the development of heating elements and the method of application for these conditions.



Fixed blade propeller type turbine runner for Chats Falls development.

There is a definite tendency toward automatic and remote control of generating stations. At one large plant in Ontario, with an installed capacity of 54,000 horsepower, remote control equipment is being installed that will enable the plant to

Chats Falls interprovincial development—Ottawa River—View of headworks showing (under short leg of gantry) small housing for head gate hoists. Outdoor gantry is for handling racks and gates.

be operated almost entirely from an adjacent station located some two miles upstream.

While very few changes have been effected in the design of governors, there has been an almost universal demand for the motor-driven flyball type of actuator, and investigations at present under way by the manufacturers will undoubtedly contribute toward considerable improvement in the reliability of current supply for the operation of these motors.

A Higher Quality Concrete

Not only have advances been noticeable in equipment and capacities of units, but there is a general increase in the recognition of the need for improvement in the qualities of construction materials. Concrete mixtures are now being designed with even greater care. The principal features at present stressed in designing concrete mixtures are density and durability. At the Chats Falls plant, these requirements proved to be the controlling elements, resulting in strengths in all cases in excess of those required for the stresses to which the various parts are to be subjected. The net result of this practice is a high quality concrete, with a low permeability and consequent resistance to damage from frost action.

—*Electrical News and Engineering.*

Cost of Rural Hydro

NOT infrequently we have heard rural residents complain of the cost of rural hydro as compared with the prices paid by urban householders. Such complaints find a ready echo from one district to another and soon the volume of criticism becomes heard in official quarters. Evidently the Ontario Hydro-Electric Commission has harkened to the demand of rural Ontario for some explanation as to the difference in cost of hydro service as between town and country. The Commission has recently issued a very comprehensive and enlightening brochure entitled "Rural Electrical Service in Ontario," which outlines the salient features of the subject in a manner which is most convincing. Any rural resident who labors under the belief that the cost of hydro service to farmers is unduly high, should obtain a copy of this pamphlet for the purpose of securing all available information on the subject.

Primarily the difficulty in rural hydro distribution is one of scattered population and greater distances between consumers resulting in a much higher capital investment per rural consumer for the necessary transmission lines with consequent higher annual costs. The Commission points out that the number of consumers served by a mile of lines is about 20 to 50 times greater in the cities than Ontario rural areas. For isolated farm consumers each service requires a separate transformer and switching equipment while the operating costs are relatively high in the country and have to be borne by perhaps three to ten consumers per mile of line instead of by some 200 or more as in the city. These and other features constitute serious handicaps to the provision of rural electrical service at low cost under the conditions found in Ontario agricultural territory and it should be appreciated that only the Commission's earnest desire to design economical methods of rural distribution together with government assistance, have made it possible to provide service to farmers at the comparatively low rates that now prevail in Ontario rural power districts.

It is true that the Ontario Government has shown commendable enterprise in providing for the extension of rural hydro service. In the first place provision was made for the payment by the government of fifty per cent. of the cost of constructing rural primary transmission lines. Then in 1930 the Rural Power District Loans Act provided that farmers desiring to take full and early advantage of hydro service could borrow from the Commission up to $1,000 for one consumer. This was financed up to a maximum of $2,000,000. In respect of wiring on consumer's premises and in respect to motors and other appliances, loans may be secured, to be repaid over a 20-year period. In the same year a second Act provided new low service charges. For instance, for Class 3 rural service, which is really a combined domestic service and power service, the basic service cost is fixed at $2.50 monthly. The Commission goes into detail in its

brochure to demonstrate that for service of a similar character the urban consumer would have to pay a service charge of about $3.00 per month. This should clearly disprove the contention that the Commission is seeking to discriminate against rural residents.

The expansion in rural service in the last few years affords clearest proof that Ontario farmers appreciate the opportunity to secure electricity for their homes and farm buildings. In 1920, there were in Ontario about 305 miles of rural line with 2,880 consumers, taking a load of 300 horsepower. In 1931 these figures had grown to 8,400 miles of line and 55,000 consumers, taking more than 31,000 horsepower. The capital investment in rural power districts is now $15,730,000, and half of this investment is represented by government grants so that rural consumers in their rates have to pay interest and sinking fund only on half the investment.

The inevitable conclusion after reading the Commission's statement of policy is that it takes a keen pride in the rural power districts under its supervision and that it has treated the rural consumer with utmost fairness. The Commission does not hesitate to declare that the rural service provided in Ontario is unsurpassed for any comparable area and circumstances. It further says: "The rural consumers do not have less consideration than the urban. On the contrary, through Government aid, they receive special advantages. The requirements for new extension of rural hydro service are at the minimum necessary to protect the consumers themselves."

It is evident that in recent years the Ontario Government has realized that for a well-balanced development of provincial resources, not only manufacturing industry but agriculture should profit by extension of electrical facilities. The policy of the Commission has been to extend electrical service to every community that can economically be reached by transmission lines. Finally it must be remembered that the rural service provided at such favorable costs could never have been provided without the co-operation of transmission networks serving the well-populated urban municipalities. These great networks are the base from which rural primary lines are extended over wide areas.

It is a significant fact that Ontario rural rates are lower than in any comparable territories in the world, and they are in important respects actually lower than even urban rates to domestic consumers in many larger cities outside Ontario. These and other interesting facts are set forth in the pamphlet referred to above, copies of which are obtainable from the Ontario Hydro-Electric Commission, Toronto.—*Simcoe Reformer.*

The Hydro-Electric Power Commission of Ontario

By A. Lennox Stanton, M.I. Mech. E., M.I.E.E., M. Amer. S. Mech. E., M.I.E. (India).

THE Hydro-Electric Power Commission of Ontario has been, from time to time, subject to attack from various interested parties in the U.S.A. In 1929, some attention was devoted to the work of the Commission in this journal* and to the attacks made upon it. During the interval of time which has elapsed since the publication of that data which dealt with established realities only, the Commission has had to deal with conditions of development deemed to merit a wider field of publicity if only, once again, to correct certain errors which have found expression.

It is established beyond all doubt that the Commission is, in the eyes of the people of Ontario, conducting its business with outstanding success, and that the principle of this business has been to create conditions whereby electricity supply may be available under more or less uniform base rates throughout every sufficiently populated area of the Province which is traversed by primary supply lines.

What follows should be interpreted solely from the aspect of recognizing that progressive advances in the electricity supply, transmission, and distribution business neither are, nor can be, limited by any single form of development outlook. The invisible elements of time and of environment necessities in relation to changing outlooks of expressed limitation in human endeavour cannot be monopolized.

The folly of attempting a constructive comparison based on the results of a policy of a publicly owned organization as distinct from an equally advanced private organization or vice versa should be self-evident.

The conditions of development in Ontario are unique, creative of obligations for meeting load demands not paralleled elsewhere. As one result, the situation arising therefrom has been productive of complications in the shape of interprovincial and international problems of an unusual order where a public utility service is concerned.

To understand rightly this state of affairs it is necessary to bear in mind the following realities:

(a) H. E. P. C. statistics of the growth of annual demand prove that development needs must be able to provide for increases of the order of ten per cent. per annum. The end of the summer in 1931 found the Commission delivering more than one and a quarter million h.p. of energy, the bulk of which was derived from thirty-seven developed hydro plants. This means that demand increases of the order of ten per cent. per annum must anticipate an availability five years hence of over two

*"The Hydro-Electric Power Commission of Ontario" by A. Lennox Stanton, *World Power*, May, 1929, Page 460.

million h.p.: this figure, presumably, will take care of the actual demand at that time, plus transmission losses, plus a preagreed-upon emergency unit reserve.

(b) Ability to meet the present annual demand and at the same time provide for future growth as far ahead as can be reasonably expected, depends entirely upon a utilization of available water power under conditions designed to secure a maximum site value. Excluding small power sites developed at widely separated places in the Province, the available economic sites are located on the Niagara, St. Lawrence, and Ottawa Rivers, but before these sites can admit of development to their fullest extent, interprovincial, international, and other vested interests have to be co-ordinated and harmoniously adjusted for the greater common good.

(c) As should be well known by all would-be investors in the hydro field, all large-scale hydro plants labour under two disadvantages;

(1) Heavy initial expenditures, by reason of the forced necessity for carrying out the major portion of the civil engineering works before any revenue can be earned.

(2) The length of time which must be allowed for between the date of actually commencing construction work on site, and its completion to a point which admits of units laid down being brought into operation for initial service. No hard-and-fast rule exists for determining this time element, inasmuch that no two hydro sites under process of development ever present an exact duplication of detail conditions for the conduct of construction work. Each case therefore has to be decided on its merits. By reason of contractual liabilities which enter into the matter, no class of construction work demands greater attention to the accuracy of preliminary detail data, or more stringent supervision during the progress of construction than hydro projects, if avoidable losses are to be reduced to a minimum. Related to the foregoing, the Commission has site works in hand, supplemented by other arrangements under the heading of purchased power, planned to provide for being in a position to meet an estimated fifty per cent. increase of hydro unit availability five years hence.

(d) A great deal of the success of the H.E.P.C. has been attributed to the availability and use made of Niagara Falls, as a hydro site affording maximum value for a minimum cost per developed h.p. There is no doubt that it was a factor in initial success, but bearing in mind that the hydro sites under development do not lend themselves to the production of a busbar grid, in the same economic way that the coalfields of Britain do, it should be clear when considered as a whole and becoming more pronounced as the annual load demand increases, that other equally and no less important factors for success lie in realizing what the labours of the Commission have represented, through obligations imposed upon them to transmit energy to distributing centres situated in localities bearing no relation whatever to aspects of development commonly given importance elsewhere. Consider by way of contract example, what is involved under the practical

necessities which require deliveries of energy under the following public supply conditions:

TABLE I

DETAIL	GROUP		
	One	Two	Three
Distance in miles from generating station........	239	238	267
Number of consumers connected for domestic service..................................	2,817	14,787	158
Average monthly unit consumption of the domestic consumers................................	142	188	35
Number of consumers connected for "Commercial Light" service............................	304	2,398	59
Average monthly unit consumption of the "Commercial Light" consumers......................	322	564	65
Number of consumers connected for power service.	43	363	3
Average monthly h. p. of power consumers' demand	2,819	10,236	28
Total number of consumers...................	3,164	17,548	220

As a further example, consider what is conveyed by the statement, during the year 1929, the average consumption of domestic consumers connected to municipal distributing services drawing energy from the H.E.P.C. primary systems, was recorded as being 122.5 units per month, or 1470 per annum.

Finally, and as is related to growth of demand on the part of the domestic consumers only, consider what is reflected by the following checked data:

TABLE II

Year	No. of Munici-palities Concerned	Number of Domestic Consumers Dwelling in Cities of over 10,000 Inhabitants	Average Annual Consumption (Units)
1914	12	55,597	261.6
1923	21	223,028	1002.0
1929	26	309,645	1646.4
		Number of Domestic Consumers dwelling in Towns of over 2,000 inhabitants	
1914	19	7,410	208.8
1923	43	34,135	721.2
1929	54	57,699	1173.6
		Number of Domestic Consumers dwelling in Villages of less than 2,000 inhabitants	
1914	18	1,859	157.2
1923	142	29,689	404.4
1929	193	55,075	806.4

(e) The population of the Province of Ontario is little more than three million, or not more than seven and a half per cent. of the 39,947,931 persons quoted in the 1931 Census as dwelling in England and Wales. Of the three million, not less than one-third dwell in rural areas, the entire area of Ontario being more than three and a quarter times the square mileage of the British Isles. The forgoing being the case, what then is responsible for the important part played by the activities of the H.E.P.C. in the life of the people, creative of demands for electricity not parallel elsewhere and which constantly make for increased avenues of employment?

The question is answered by stating that from the commencement of the Commission's activities the basic principle in relation to consumers was, and still is, one of establishing conditions whereby and whereunder, regardless of what class of service it related to, the whole of the people of the Province could secure a maximum economic benefit from the availability of an electricity supply.

This was accomplished by the creation of a rate structure based on the principle of service at cost. Moreover, as interpreted in Ontario, such a structure means that the cost must be the lowest possible cost at which energy can be supplied consistent with sound economic procedure. Resulting therefrom, each class of consumer (and as closely as practicable each individual consumer) is charged for service in terms of actual cost covering any specified period of time.

Paradoxical though it may appear to the opponents of such methods, the experience of the comparatively short period of a quarter of a century in Ontario, show that wherever this basic principle has been introduced it has invariably proved creative of financial stability, in the sense that through the operation of bearing its own share of actual cost, each class of service becomes more or less independent of fluctuations, which react detrimentally on rate structure commonly found in practice elsewhere.

Now it is not so generally remembered as it should be, that the H.E.P.C. commenced its operations as a power purchasing enterprise, confining its initial activities to the business of transmission and distribution. But a few years' experience were required, however, to prove that the only way the Commission could hope to rightly fulfil its public obligations with any degree of security and stability was by (*a*) purchasing outright, if possible, such already developed generating sites as, located within the Provincial jurisdiction, justified it; (*b*) acquiring legislative authority for powers whereby and through which it was enabled to acquire by purchase, lease, or otherwise, and construct, maintain, and operate works for the production of electrical power or energy by the use of coal, oil, or any other means whatever. In addition to the foregoing, it also acquired powers requiring any person generating, transmitting, or distributing electrical power or energy in the Province, to supply so much thereof as the Commission may require.

These powers were embodied in what is known as "The Power Com-

mission Act of Ontario". A careful perusal of this Act cannot but convince the greatest disbeliever in the value of legislative drafts, notable as they are for costly ambiguities and lack of clarity in meaning, that no matter what others elsewhere may or may not do, the fact remains that those responsible for the passing of the main clauses in this Power Act were far-seeing in their vision, bold in their conception, and clear in their determination to, as far as able, secure for and to the people of the Province of Ontario the fullest advantages possible which accrue from the availability of a cheap and plentiful supply of electricity.

Of comparatively recent date, considerable adverse comment has been made of the fact that the H.E.P.C. has been hard pushed to establish a development programme which could keep pace with the growth of prospective demand, and this in spite of the world-wide industrial depression.

What this has meant may be gathered by realizing that whereas the December 1922 peak load was 618,867 h.p. the peak load of December 1930 reached 1,286,278 h.p., an increase of over one hundred per cent. in eight years. Accordingly, the Commission has had no option but to explore every avenue adjacent to, but outside, as well as inside, the boundaries of its own jurisdictional control which afforded possibilities for increasing its ability to meet estimated future power demands, required on annually increasing scales.

Thus it comes about that, quite apart from its own hydro site developments, or of others located within the the Provincial jurisdiction of Ontario, deferred delivery large-scale contracts have been made with hydro Power Companies operating in the adjacent territory of the Province of Quebec.

The immediate future having been secured by sensible methods of interdependence which differ in no way from those employed elsewhere and which, moreover, accord in every way with the principle under which initial activity came about, it will be obvious the Commission cannot faithfully fulfil all its obligations to the public and at the same time own and control all the generating sites from which its transmission system draws energy, unless it turns to and adopts some form of primary energy for its generating stations other than water.

It has been suggested that the solution lies in laying down high-grade steam generating stations, but for Ontario that means large-scale annual purchases and long-term deliveries of solid fuel through agents or direct suppliers located where no jurisdictional control whatever would be possible.

It will therefore be self-evident that for so long a time as it is possible to secure bulk supplies of hydro-electric energy by purchase under favourable rates from generating authorities in adjacent Provinces, which in quantity meet all future demand scales over and above what the Commission's own hydro plants can produce at any time, after making due allowance for reserve units, such a policy is to be commended. The conditions governing continuity of service through agreements to take favourably priced purchased bulk supply, via generating sites located

directly adjacent to territory under the Commission's own jurisdiction, usually permit of providing for a larger margin of safeguarding with a minimum capital expenditure than any other alternative applicable to the stated situation.

CONCLUSIONS

As distinct from that common to purely industrial projects, the efficient development of water power sites, in close correlation with an expanding public supply utilized for all purposes, is limited by a time element of construction which cannot be ignored. Resultant upon the nature of practical engineering aspects entering into the matter the more scattered and widely separated such sites are, the larger becomes the capital expenditure required for their separate, yet maybe coincidently conducted, development, prior to the establishment of conditions whereby the ability to earn revenue can make itself felt.

Although the basic principles of an at cost rate structure have found application in Ontario during the whole of the period of time in which experience of it has been gathered by the H.E.P.C., little or no evidence exists to show that the public elsewhere have been educated to know how it is applied, or what its application means in relation to conceptions of an existing order. Nor does it appear to be realized, as it yet must be, that it is not an appendage of hydroelectric, of coal, or of oil, but the application of a principle exclusively based on an evaluation of the whole integrated elements entering into the actual cost of a utility service and the use derived therefrom.

In practice under similar powers to those which govern its administration in Ontario, it provides incontrovertible evidence that the problems of meeting an expanding load demand with ease, and of maintaining it with high efficiency without financial loss, form increasingly important elements which do not admit of any rightful solution correlative with a fulfilment of the obligations imposed on the administration, saving only a co-ordinated concentration of control is in force founded on co-operative endeavour of the highest order. In so far as Ontario is concerned, the results to date represent the cumulative effort of capable administrators and most loyal workers. That no one has attempted to emulate them, where (as in Ireland for example) conditions existed favourable for testing out its value, merely shows no one is ready yet to meet what it demands in the way of expressing a similar type of creative endeavour.

What that creative endeavour has demanded and what is foreshadowed as being required in the future from they who carry on in Ontario may best be judged from Tables III to VI.

TABLE III

Year 1929-30, units generated	4198.9 millions
" 1926-27, units generated	3904.4 "
Increase in the units generated	294.5 millions
Year 1929-30, units purchased	897.3 millions
" 1926-27, units purchased	201.8 "
Increase in the units purchased	695.5 millions
Year 1929-30, units G. and P.	5096.2 millions
" 1926-27, units G. and P.	4106.2 "
Increase in the units G. and P.	990.0 millions
Year 1929-30, total mileage of transmission lines	4635.87
" 1926-27, total mileage of transmission lines	3350.40
Increase in the total mileage of transmission lines	1285.47

TABLE IV

RURAL LINE SERVICE

Year	Miles of Line	Number of Consumers			Power Supplied
		Hamlet	Farm	Total	
1929–30	6830.47	25,355	21,360	46,715	26,782 H.P.
1926–27	2921.78	15,526	9,757	25,283	13,273 H.P.
Increases	3908.69	9,829	11,603	21,432	13,509 H.P.

TABLE V

Year	Number of Consumers	
1929	Domestic service, all municipalities	424,419
1927	Domestic service, all municipalities	387,573
Increase	Domestic service, all municipalities	36,846
1929	Commercial lighting service, all municipalities	70,106
1927	Commercial lighting service, all municipalities	64,039
Increase	Commercial lighting service, all municipalities	6,067

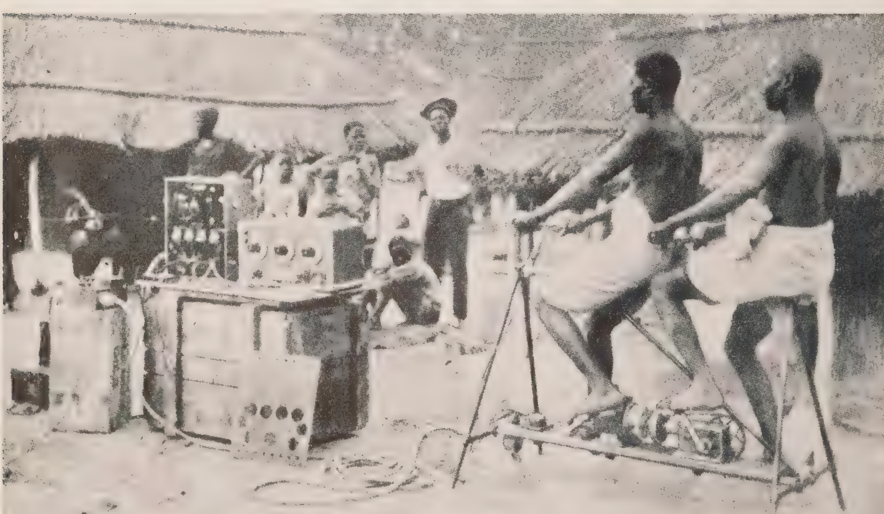
TABLE VI

ONTARIO MUNICIPALITIES POWER SERVICE; NUMBER OF CONSUMERS CONNECTED IN CITIES OF 10,000 OR MORE INHABITANTS ONLY

Year	Number of Consumers	Average Monthly H.P.
1929	9,505	364,367
1927	8,329	272,729
Increase........	1,176	91,638

—*World Power.*

"Negro"-Electric Power



A novel type of apparatus constructed by the Marconi Company for use in Northern Rhodesia to link up isolated administrative posts in the territory with each other, and with Government headquarters. Power is derived from a tandem pedal-driven rotary converter, capable of generating 140 w., and communication has been maintained satisfactorily over distances up to 500 miles. The transmitter is the left-hand instrument on the box in the centre of the picture.

Neon Tube Lighting

Characteristics, Application and Load Effect on Installation.

VARIOUS gases are used besides neon in the so-called "Neon tubes". In manufacture each end of the tube is fitted with electrodes made from high conductivity metal, e.g., copper, nickel, or iron, bared inside the tube and heavily insulated outside, into which the necessary wiring conductors are securely fitted or welded.

All air is then exhausted from the tube, and any extraneous matter which may have clung to the walls of the tube or the interior electrodes expelled. After drying out, the required gas is pumped in at a predetermined pressure, and allowed to saturate. Neon gas itself produces the familiar red glow when lit, whilst argon, though not of any commercial value, owing to its poor luminosity, shows as faint lavender. Helium gives off a whitish glow, but is not so efficient and is more expensive than neon. Gas forming on discharge primary colours might be proportioned to produce a white light, without utilizing the other colours formed by the spectrum. By mixing mercury and argon a blue glow is obtained, this and the colours previously mentioned being used with ordinary glass tubing. If a combination of argon and mercury gas is used in a yellow glass tube, the resultant luminant will be green, whilst to obtain an indefinite fluorescent outling uranium glass may be substituted.

Operation Characteristics

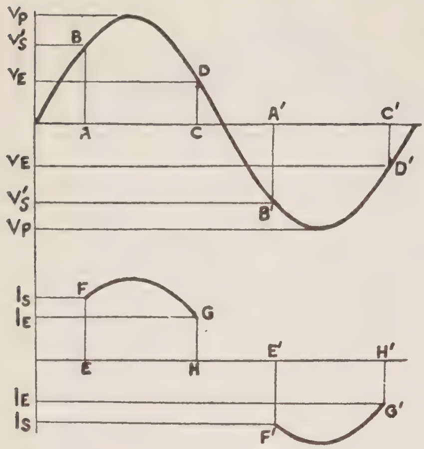
The properties of all these gases are such that once luminosity is established, by the flow of current in the tube, they will continue to glow, or discharge, at a much decreased e.m.f. with a minimum of current.

Standard low voltage a.c. systems will not provide a high enough e.m.f. to produce this desired condition for commercial installations, except with small lengths of gas-filled tubing.

Due, therefore, to the inherent properties of these gases, a step-up transformer is employed for this initial "striking", but the voltage required to maintain satisfactory running conditions is only about half that needed initially.

In consequence of this the current wave does not fill the whole of the sine wave curve, as it commences late and finishes early, as shown in the diagram. The current will, therefore, have a tendency to rise, so that any high-voltage system used in conjunction with these tubes must be such as to limit it immediately after the luminous condition has been obtained, otherwise the tube would be destroyed. The necessity for such a current limiting device in the circuit requires either the introduction of choke coils on the primary or secondary side of the transformer, or the use of a stray-field transformer as a means to attain this end.

The neon circuit has a low power factor. In the accompanying illu-



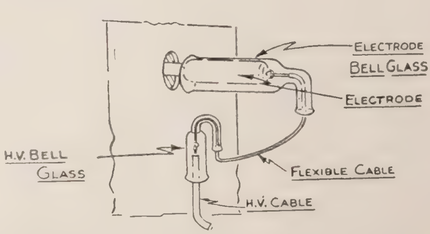
Relation of voltage and current in a neon tube.

stration are shown the voltage and current characteristics of a neon tube in their relation to a complete a.c. cycle during the establishment of luminosity in a neon tube, and subsequently behaviour. In the top portion, AB—V′s represents the striking pressure, and CD—VE the extinguishing pressure in each half cycle. The current suddenly rises to a value Is—EF, correspondingly at the striking value V′s. Then follows the path shown as FG, until reaching IE, when it instantaneously falls to zero, as indicated by GH, corresponding to VE, the extinguishing pressure. Luminosity ceases between the points D and B′, in the curve, but on the latter being reached, the sequence is repeated, the current in the tube passing in the opposite direction Is—E′F′ to IE—G′H′.

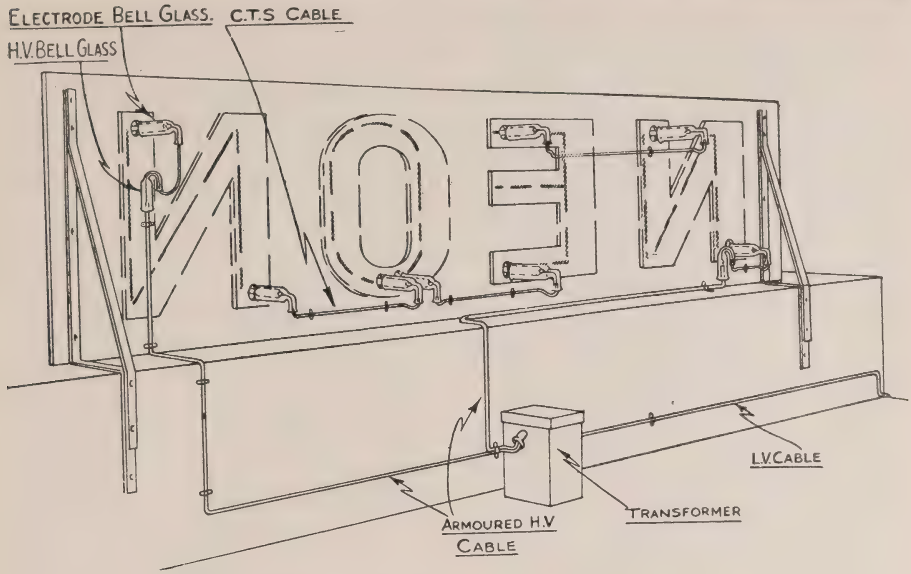
Effect of Power Factor

As the input of the tubes is low, they do not have any material effect upon any distribution system, unless the loads are in sufficient quantities to produce a considerable sum total. An average installation has a power-factor of from 0.4 to 0.5, dependent upon the design, whilst its imput may vary from 0.25 kv-a. for a shop window panel up to 3 kv-a. for a lettered sign or window frame. In the case of theatres the total sign load may not exceed 10 kv-a. out of 150 kv-a. required for the whole building. Compared with induction motors frequently of larger size, whose power factor may not be above 0.6 or 0.65, the adverse effect of signs may be treated as negligible. A condenser would raise the power factor, but it would increase the cost by approximately 5 to 7½ per cent.

The transformers used for stepping up from the public supply must be totally enclosed, preferably of the oil or compound-filled type, with terminals suitably shrouded. As they are placed adjacent to the tubes on the consumer's premises, care should be taken of the means of connecting up the high-voltage side with heavily insulated weatherproof cables. Certain local rules apply as to the secondary or high-voltage side, but 10,000 and 5,000 volts are in common use, and so provided reasonable precautions are taken against interference by unauthorized persons and suitable notices posted no danger exists.



High-voltage connections of neon tubing.



Characteristic connections of a Neon sign.

TRANSFORMER REQUIREMENTS

No definite rule can be applied to the number of transformers to be used on any display, for questions of voltage drop have to be considered in conjunction with other factors. In the case of a straight tube, one transformer may suffice for every 15 to 20 ft. of tubing. Signs differ in form and size, so that the sectionalised circuits are divided to suit individual requirements. In this connection it is advisable to have section fuses to localize faults, besides a main switch on the low-voltage side. Technically speaking, there is no reason to limit the secondary voltage to the figures given above, but the initial pressure required precludes the commercial use of d.c.

All neon tubes are cold illuminants, and such rapid development is being made that white light is obtainable, but so far no notable progress has been made towards using it as a medium for public lighting owing to the high initial voltage required for striking.

At the same time, research work carried out in connection with the discharge of gases in tubes has led to interesting experiments in which hot thermionically emitting electrodes have been substituted for those described above. With tubes of this pattern it has been found that the ordinary working voltage will suffice to create and maintain illumination. It remains, therefore, to develop these to give a white light with high efficiency on a commercial basis.

Already a mixture of neon and mercury, in a tubular fitting, has been made, emitting a white light at a higher efficiency than an equally rated tungsten lamp. This type of light is understood to possess the same inherent characteristics as those attributed to the cold neon tube pattern.—*The Electrical Review.*

Rural Class 1B Permissable Installation Increased

The Commission's experience regarding equipment that might be used by a Class 1B rural consumer has shown that the limit of capacity has prohibited certain desirable appliances. It has therefore ruled that the limit of capacity for this class be increased, while retaining the same size of service as formerly, and a letter has been sent to all users as follows:—

"Up to May 15, 1932, Class 1B consumers in Rural Power Districts were permitted to use permanently installed appliances up to 750 watts capacity. The regulations have been altered so that after the above date Class 1B consumers (which are the smallest class of consumer) may use permanently installed appliances up to 1,320 watts capacity. Appliances of this size may be used by connecting to properly installed wall receptacles or base plugs. This will permit the use of hotplates and small ranges or rangettes on Class 1B service, or on any other class of service in a Rural Power District.

"With this change in the regulations, the small consumer will be able to make considerably more use of his service as the small range or rangette of the above stated maximum capacity, as developed by various manufacturers, has proven quite satisfactory for cooking for the ordinary summer cottage or for customers whose requirements are not very great.

"There are a number of manufacturers making these small ranges and cooking devices and we are enclosing for your information a number of circulars of some of these manufacturers. If you are interested in one of these devices, we would advise your communicating direct with the manufacturer, as intimated in these circulars. You will probably receive from time to time further information from these or other manufacturers to enable you to make a proper selection of one or the other of these appliances.

"By sending you this literature, the Commission is not recommending any particular make of appliance, simply passing information on to you for your guidance, without recommendation as to one manufacturer's equipment over another. The choice of any of these appliances is left entirely in the hands of the consumer."

"Well Done Corkill"

Joe Corkill, patrolman, located at Owen Sound, is to-day a very pleased man. His faithfulness in practicing resuscitation gave him the knowledge and confidence in applying the prone pressure method whereby he was instrumental in keeping alive Ernest Johnston, an eight-year-old boy, who had disappeared beneath the ice of the Sydenham River. This knowledge and its application enabled Ernest to be returned to his parents. Let me give you Joe's own report of the incident:

"I was within a block and a half of the river on the morning in question when I heard the Fire Department coming up the street. As they passed me, I noticed they had a boat on their truck and concluded that someone had fallen in the river. I ran to the river and found that a young boy had just been taken out of the water and the firemen had commenced work

on him. When I arrived, the firemen seemed well satisfied for me to take charge and I started working on the body without further delay. The firemen had been doing the best they could, but appeared to have no conception of the proper way to change over, and I realized that every second was precious. Consequently I worked until one of the local Hydro Commission linemen, Mr. Fred Breckenborough came on the scene and he relieved me, twice after I had explained the proper method of changing over without losing time. After about twenty minutes work, the doctor arrived, and at that time the case looked hopeless. However, we kept up the work incessantly, Mr. Breckenborough relieving me at intervals, and after about forty or forty-five minutes from the time resuscitation had been commenced, I noticed a slight response from the patient. I drew the doctor's attention and he asked me to rest, but to maintain my position ready to start again if respiration failed. During this period we had a number of hot water bottles around the body, and as many blankets as possible without interfering with our work. In a few seconds the boy tried to cry and the doctor concluded he had recovered sufficiently to be taken to his home nearby, where he made a complete recovery. I called on him the next morning and he could not understand why he was not allowed to go out to play as he felt first-class. He did not even contract a cold from his exposure."

O.M.E.A. and A.M.E.U.

CONVENTION

at Bigwin Inn, Lake of Bays

June 23, 24 and 25, 1932

See Page 146 for Programme

At Your Service

Do you know that the

SALES DEPARTMENT

of the

Hydro-Electric Power Commission

is AT YOUR SERVICE ?

YOU are cordially invited to submit to the Sales Department any request for competitive prices on all types of Electrical Equipment and Appliances and they will be pleased to handle any orders you may have for such equipment, either for New Construction or for Maintenance and should be able to save you money.

Many Municipalities avail themselves of this service and are well satisfied with it. Are you doing the same ?

The private telephone affords an easy means of securing prices and other information promptly.

YOUR SERVICE DEPARTMENT is

THE SALES DEPARTMENT

110 ELM STREET ANNEX

THE BULLETIN

Published by
HYDRO-ELECTRIC POWER COMMISSION
of Ontario

190 University Ave.
Toronto

Subscription Price $2.00
Per Year

Hunta-Sudbury Transmission Line

By A. V. Trimble, Chief Construction Engineer, H.E.P.C. of Ont.

IN August, 1931, the Commission completed the construction of its section of the 132,000 volt transmission line from the Abitibi Canyon to Sudbury. This section of the undertaking lies between Hunta, on the Canadian National Railway, 12 miles west of Cochrane, and Sudbury. The remaining stretch between Hunta and the development at Abitibi Canyon is being built by the Power Company with whom the Commission has contracted for power.

It is the Hunta to Sudbury section of the line that we shall consider in this short article, which is written from the construction rather than from the Engineering point of view, the latter being outlined in the BULLETIN of November, 1931. The building of the line was carried out by the Commission's Construction Department, which, to as great an extent as possible drew from local sources the large body of field workers required. This procedure was in accordance with the Commission's general policy in this regard, where the locality in which any job is situated is called on to supply to the fullest extent compatible with economy whatever labour, material, transportation facilities and other requirements available.

Natural Obstacles to Construction

Few people not engaged in construction realize the effort involved in building a line such as this. Into this record must be read the struggle against the ever present forces of nature: the discomforts of handling and erecting metal structures in sub-zero temperatures and of combating the myriads of insect pests under blazing skies in summer: the difficulties of transportation and of stringing out cable in thirty inches of snow or through miles of muskeg swamp. These are features which will receive their due weight only from the experience and imagination of the reader, but nevertheless they comprise a no small part of the cost and effort of construction.

Topography

The distance from Hunta to Sudbury, along the practically straight

CONTENTS

Vol. XIX **No. 6**

June, 1932

line route taken by the transmission line, is 192 miles. Between Hunta and LaForest the country traversed is of the kind usually described as "virgin bush". Fringes of settlements are touched at Hunta and Timmins, and from LaForest south to Sudbury intermittent stretches of farming country are encountered, but otherwise the country is practically un-untouched by man, an unbroken stretch covered with heavy coniferous growth, varied in places with birch, poplar and alder, covering muskeg, plains and low rolling hills in the northern part of the line, and steep rocky hills varied with open farming country in the southern quarter. The line runs almost due south from Hunta to Timmins then follows generally the line of the Mattagami River and on southwards through West Shining Tree, crossing the C.N.R. near Thor Lake, thence direct to Copper Cliff and Sudbury.

Type of Line

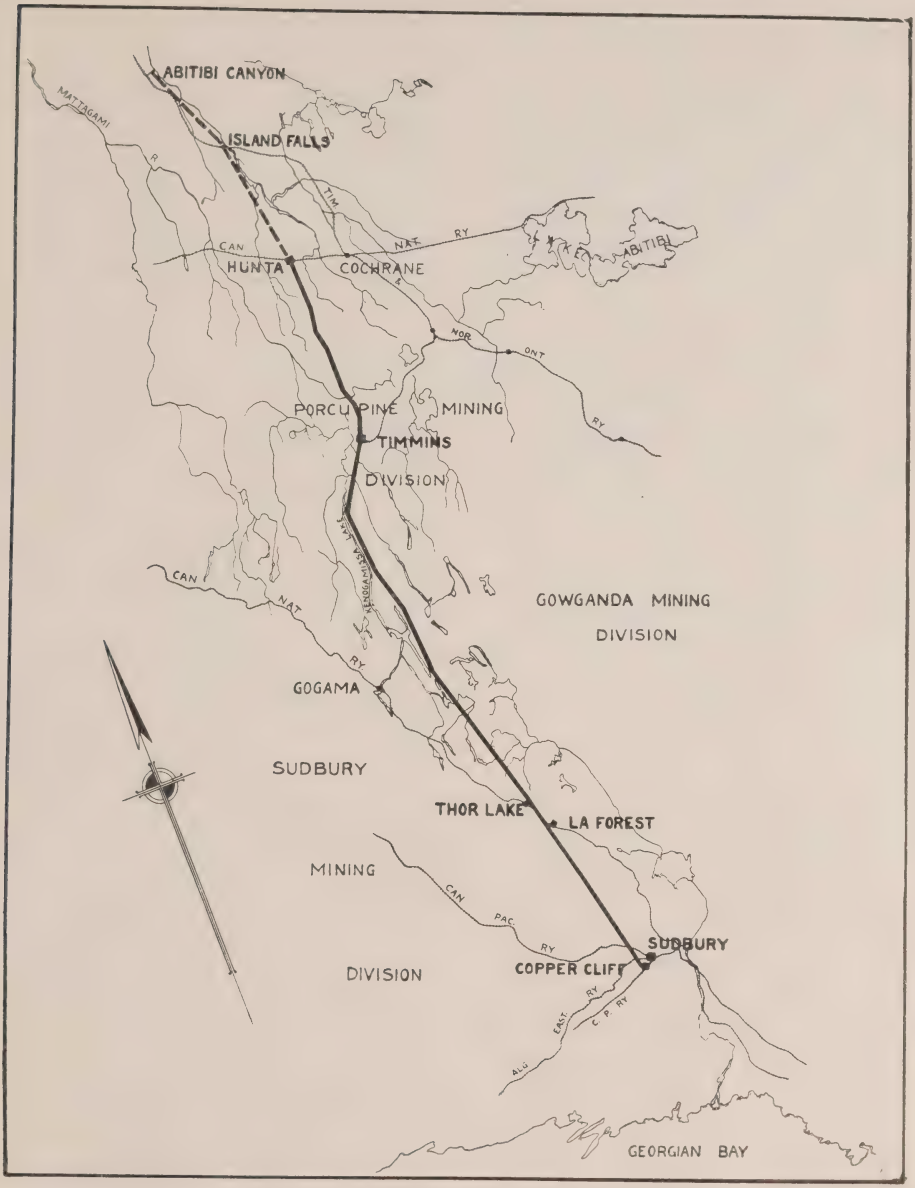
Between Hunta and Timmins, a distance of forty miles, advantage was taken of a wide right-of-way cleared some years ago by the Hollinger Mining Company. South from this point a new right-of-way, 130 feet wide, has been cleared. In the Northern section the transmission towers were erected on foundations established by the mining company, spaced seven to the mile: over the rest of the line they average five per mile or about 1,100 feet from tower to tower.

The towers are of heavily galvanized steel, shipped in individual pieces and bolted together as assembled, and are about 82 feet 6 inches above ground. Below ground are eight feet more of steel in the footings, either fastened to rock or held down by a heavy grillage of steel. The average weight of the towers is about 4½ tons. The power conductor is a cable three-quarter inches in diameter, of sufficient strength to span the distance between towers and at the same time of sufficient cross-section to provide ample current carrying capacity. Two power circuits of three cables each are carried by the towers, as also a single five-sixteenth inch ground cable. The power cables are carried by suspension type insulators, of eight sections each, at the ends of the three arms on each tower, the power being transmitted at 132,000 volts.

The telephone line for operating needs is a single metallic circuit carried on wood poles paralleling the tower line, except for the southerly thirty miles, where, on account of the rocky nature of the country, it is carried on the steel towers.

Access to Line

The actual construction of the line involved first of all the choosing of



Map Showing Route of Hunta-Sudbury Transmission Line.

suitable points on the railroads from which men, materials and supplies might be transported to the line. Seven such points were available and were used: viz.: Sudbury, LaForest, Thor Lake, Westree, Gogama, Timmins and Hunta. From these stations tote roads were built to the nearest point of the line to a through road constructed along the whole

length of the line right-of-way. Camp sites were selected at eight or ten mile intervals, where camps were established as the progress of the work required. Clearing of the right-of-way was, of course, the first detail undertaken and was carried on simultaneously from several initial points beginning as soon as access to the line had been established and camp accommodation made available. The clearing was begun August 10, 1930, and completed by January 31, 1931. The total area cut, including the forty miles already cleared between Hunta and Timmins, is about 3,100 acres, or an area equivalent to over thirty good sized farms. By this latter date the system of roads, both into and along the whole length of the line, had also been completed, and the transportation of the considerable tonnage of line materials well under way.

Transportation

Transportation, in country such as this transmission line traverses, is a major problem. Except over restricted areas near each end of the line, permanent roads were nonexistent, so that the moving of the major part of the material over the rough tote road, many miles of which is corduroyed over swamp and which traverses many rivers and creeks, is out of the question economically during the Summer. Advantage was taken of Winter conditions, when the snow provided a smooth road surface and the ice bridges over the rivers. As soon as supplies of tower steel, cable, insulators, hardware, and other materials were available, they were distributed along the line. A system of checking at each railway distributing point enabled a complete tower to be shipped and dumped at its right site, previously staked and numbered, without re-handling. More than 100 teams, and four heavy tractors, were engaged on this work, which was completed by the Spring break-up. In addition to the materials for the actual construction of the line a tremendous quantity of food for both men and horses, camp supplies and equipment such as bedding, beds, lumber, oil and tools had to be handled, including much perishable food material which had to be hauled during the Summer.

Material Quantities

The actual weight of permanent material in the line is 12,700,000 lb. of which tower steel comprises 8,600,000 lb., insulators and fastenings 620,000 lb., and cable 3,480,000 lb. Telephone cable and poles, tools, food, equipment, etc., added another 1,800,000 lb., so that the whole amount of material handled from railhead amounted to about 14,500,000 lb. When it is realized that the total movement was equivalent to moving approximately 112,000 *tons* a distance of one mile some idea of the magnitude of the task may be obtained.

Camps and Welfare

The majority of the camp buildings used on this work were constructed of fibre boarding on timber framework. This construction provides a building well insulated against heat in Summer and cold in Winter, thus adding greatly to the comfort of the men occupying them. The buildings were made in sections to facilitate movement from site to site. Provision was made for bathing facilities, and

as a means of entertainment, radios were furnished for each camp.

The importance of keeping the working force in good health and free from epidemics necessitated a continuous medical inspection over the whole line by a resident physician. Sources of drinking water supply were tested frequently and periodic physical examinations of the personnel undertaken. Inoculation against typhoid and vaccination for smallpox was given to every man on the job. An extremely high standard of freedom from serious ailments resulted from these measures, which was maintained until the completion of the line.

Hydro Efficiency

AT 9:10 p.m., May 5th, 1932, trouble developed in the 44 kv. winding of the 300 kv-a. transformer at Winchester distributing station, interrupting service to Winchester and vicinity. A spare transformer was loaded and shipped by rail from Smiths Falls over night and was placed in service at Winchester on May 6th, at 6:10 p.m., the interruption to Winchester totalling 21 hours.

Comment on the speed and efficiency with which this work was carried out by the Commission's staff was made in the May 12th issue of *The Winchester Press* under the heading "Hydro Efficiency", special mention being made of the names of Mr. T. O. VanBridger and Mr. J. B. Briggs in this connection.

"There may be some fault-finding about Hydro Affairs, but when it comes to Hydro Efficiency there is no room for complaint. This fact was fully exemplified at this station last week, when the large transformer that stood just outside the service station, and looked like a railroad water tank, was burned out on Thursday evening last. To Mr. T. O. VanBridger, the local Superintendent, it came as a complete surprise as there had been no indication of any defect in the big transformer. Nevertheless it failed and plunged this and adjoining localities connected with this system in darkness. But Mr. VanBridger is one of the Hydro 'Efficiency' employees, and he did not hesitate, but got into immediate action. A new transformer had to be procured. This was secured at Smiths Falls. It had to be loaded on a freight and brought to Winchester. The old transformer had to be removed. Now one of those transformers weighs in the neighborhood of eight tons, and they have to be handled with care. Clumsy brutes to move, and tottlish. But it didn't take Tommy long to get his gang together with ropes, tackle, bars, rollers and all necessary paraphernalia, and by the time the new transformer was here at 10:30, Friday morning, the old one was out of the way. The new transformer had to be taken off a freight car and rolled on planks to the highway, then rolled along the highway to the service station, placed, connected

with the power wires and tested. And all this was accomplished so that by five o'clock Friday night the power was again on, the lights burning, the motors humming and everybody happy. Of course it is always proper to give the head of a system the praise, but all the same Tommy wouldn't have been able to have made the record he did if he had not with him a thoroughly efficient staff who understood their work. And they did work, not like men who watch the clock, but as though they were personally interested in the work and wanted to serve. It is such service that has built up Hydro Efficiency and made it so popular with the public. The Press extends congratulations to Supt. VanBridger and his staff.

"Since the above was put in type the Press has been informed that without the assistance of Mr. J. B. Briggs of the operating Department of the Hydro System, and his able staff at Smiths Falls, the work of installing the new transformer would have taken several days. After a phone message from Mr. Vanbridger, Mr. Briggs got his men together and they worked all Thursday night to get the new transformer loaded on a freight car ready to be shipped early Friday morning. They then came down early in the morning, bringing with them their equipment, and with the assistance of the local men, and a few helpers from Morrisburg, the work was accomplished in the short time it was, and the users of Hydro in this section suffered little inconvenience. As stated before it is a practical evidence of the efficiency of the Hydro System and their loyal staff of employees."

Application of Hydro-Electric Power to Farm Work

Article No. 25

Adaption of Commercial Mechanical Refrigeration on the Farm

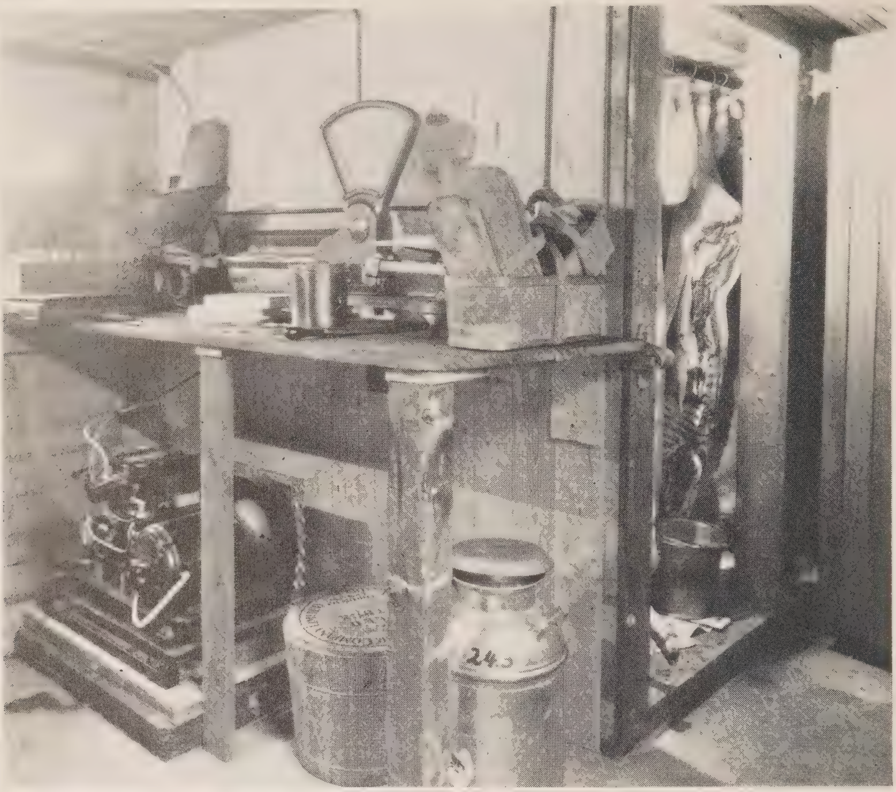
ADJUSTMENTS in our economic system, which are each day manifesting themselves by radical changes in our outlook on industry, commerce and transportation are likewise taking place in the rural life of Ontario. The farmer, as well as his brother in the industrial centre, be he the humblest employee or the highest executive, is confronted with problems of no small magnitude. To the degree with which he meets and solves these problems will depend his success or failure in withstanding the strain to which all classes of people are subjected at the present time.

The vocation of the farmer is frequently considered as different to, and in fact divorced from that of the industrialist. Yet placed side by side the problems of each have a close resemblance. Each is engaged in the production of finished or partially finished products from raw or primary sources. Each must, in his own way, find a market for his products. Factors such as the cost of raw materials and labor are mutually almost uncontrollable, and they are both, to a greater or less extent, subject to the influence of competition and general market conditions on the prices which they finally receive for their products. To be successful, the farmer, no less than the industrialist, must possess and exercise to the highest degree the characteristics of foresight, executive management, courage and resourcefulness.

An interesting example of this has recently attracted our attention. It has to do with the adaption of mechanical refrigeration to the business of farming. A group of farmers in what might be termed the "supporting area" of the municipalities of Kitchener and Waterloo have installed mechanical refrigerators on their farms for the purpose of cooling fresh meats and dairy products prior to marketing them.

Municipal by-laws require that before being offered for sale in the city of Kitchener fresh meats must be cooled to 50° fahr. and milk to 55° fahr. Heretofore, this regulation precluded the farmers from merchanting these products during the warmer months. In the winter they could attend the market but in the summer they disposed of their hogs and milk to the packers and factories and at much lower prices than those which they could obtain by marketing.

The equipment used in all cases is similar. A cooling room approximately five feet by seven feet was built, the walls, floor and ceiling containing about four inches of insulating material. In the room is a cooling coil connected by tubing to the compressor unit located just outside. The compressor is driven by a three-quarter horsepower motor. The temperature is controlled automatically,



Compressor unit, weighing equipment and partial interior view of the installation of Mr. Leslie H. Witmer, lot 37, G.C.T., Waterloo Township. The smoothness of operation of the compressor is indicated by the absence of visible vibration, although the unit was in operation when the photograph was taken.

the equipment requiring no routine attention save oiling.

The accompanying photographs show typical installations. In most cases hogs are killed once a week and at present at the rate of about two hundred per year. An increased revenue of approximately $5.00 per hog is received under the new method, which on the basis of two hundred hogs per year gives a gross additional revenue of about $1,000.00 per year. The cost of the complete installation is in the neighborhood of $700.00 but this depends largely on the capacity of the equipment.

The consumption of current by one unit between May 17th and June 2nd, a period of sixteen days of moderate weather, was 54 kilowatt-hours. On this basis the cost under a class 3 rural contract would be approximately $4.50 per month, including service charge. In very warm weather the cost of operation would be higher, as more refrigeration would be required. On the other hand, during the winter months the consumption would be negligible.

Under the conditions just described it is evident that the use of mechanical refrigeration, for these farmers at least, is a good investment. Allowing annual fixed charges at 10 per cent. or $70.00 (including interest on the investment at 6 per cent.), together with an operating cost, including service charge, of $60.00 per annum, the yearly cost would appear to be well covered by $130.00. With a possible increased gross revenue of $1,000.00 the amount of $870.00 is left for payment of labor and surplus earnings or for the paying back of the installation cost, and $170.00 in addition.

Interior of cooling chamber and compressor unit on the farm of Mr. H. W. Bean, lot 9, concession II, Wilmot Township. Note the thickness of the insulated door. The walls, floor and ceiling are equally well insulated.

Substandard Electric Water Heaters

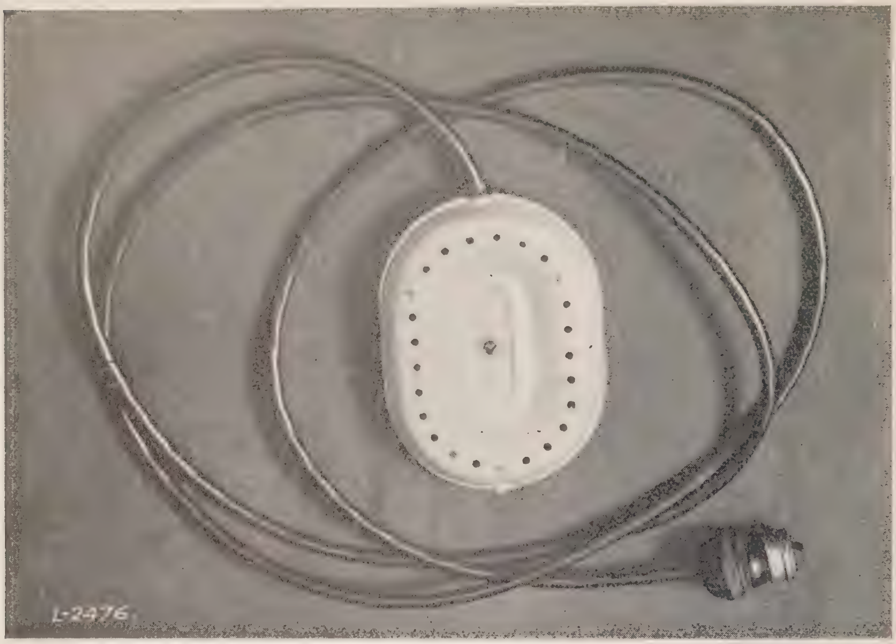
IN the September 1931 BULLETIN, an article was published describing the efforts of certain manufacturers to market substandard and dangerous water heaters in Ontario. The Commission's Approvals Laboratory made energetic efforts to stop the sale of these heaters at that time, and it appeared that their efforts had been almost completely successful before the end of the summer. Evidently, however, these manufacturers think that the season is again open as heaters of the same type as those condemned last year have appeared on the market.

These heaters have almost without exception been condemned by inspection authorities and by those interested in public safety throughout the United States and Canada. They are of two types: one for connection to a faucet, and the other for immersion in the water to be heated. In both types a bare wire carrying current is in contact with the water. This introduces a shock hazard which may be very serious.

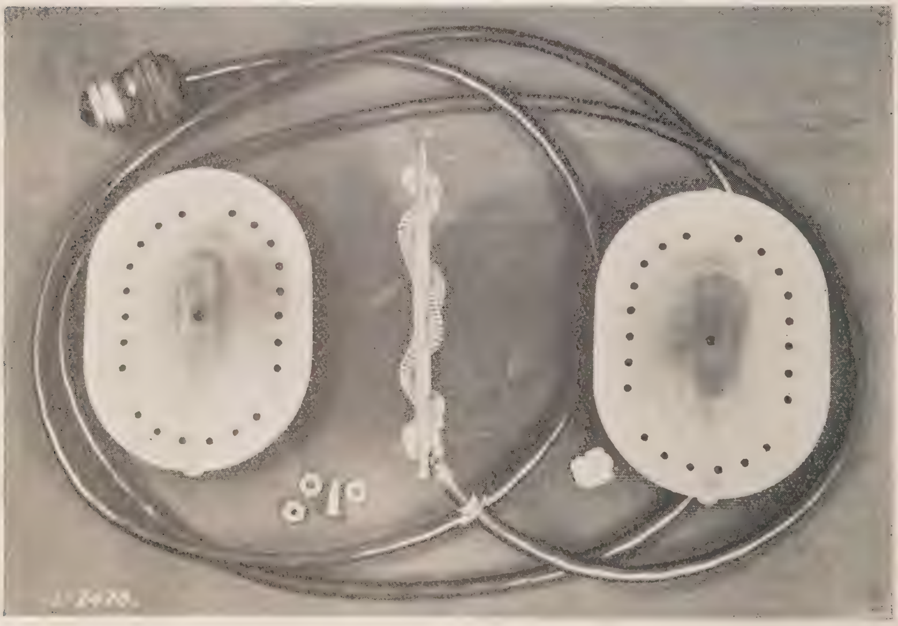
In nearly all cases the manufacturers use high pressure methods of salesmanship, as the following quotation from instructions issued by one Company to its salesmen will show:

Always Use Small Amount of Water
Its the Demonstration that Sells the Lux

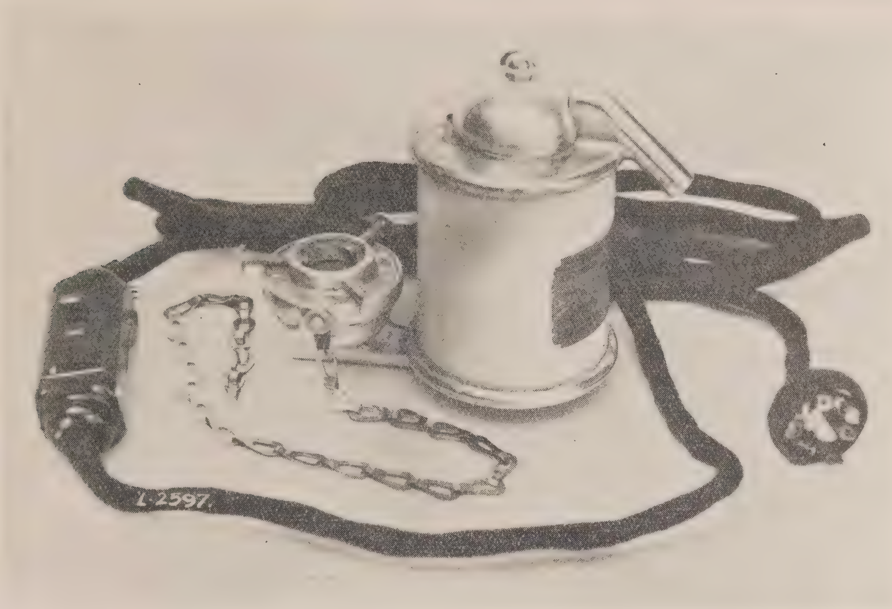
"If the housewife furnishes you with a large amount of water pour some of it out and tell her politely that you only need a small amount. You haven't time to wait for a large amount, your time is too valuable.

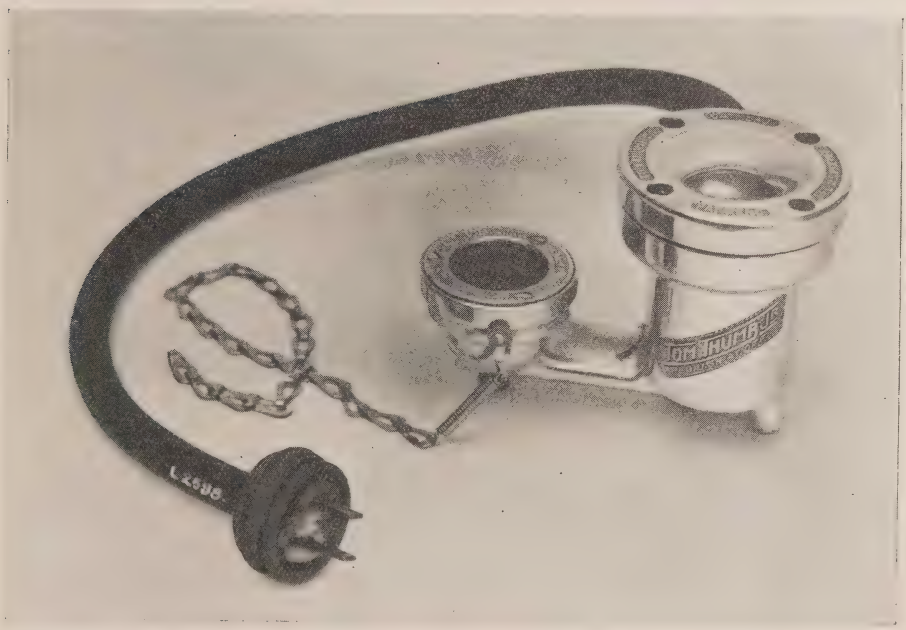


Assembly of a typical Immersion Water-Heater.



Exploded view of a typical Immersion Water-Heater. Note the bare wire used as heating element.





Samples of Faucet type Water-Heaters.

If she asks you if the Lux will heat a large amount of water tell her that it will do so in proportionate time. Never demonstrate in a bathtub of water as the Lux will not heat a bathtub of water. The Lux

will heat a sufficient amount of water for a bath however by heating a small amount in a tub say about three or four inches deep and then cooling it with cold water to the temperature required, water can be heated very very quickly in a pail with a cover on it. You should always have three or four,—15 or 20 ampere fuse plugs with you at all times. In some houses they have old plugs which are weak and once in awhile they might blow out—you can replace it for the lady and go right ahead with your sales talk.

"Remember that the Lux is a sight seller and depends upon its demonstration to sell itself. If you do not demonstrate it correctly you won't make a sale. So do it this way:

"Ask for a small pan of water—the smaller the amount the better. Place the heater in it so that it is entirely covered. Then plug in socket and turn on current. You will note that the Lux makes a simmering sound right from the start—soon it steams and before you know it—it is boiling violently. The sound of the steam and the boiling take the housewife by surprise and that is the secret of the demonstration. When she is surprised she is sold. So your demonstration must surprise her and the quicker the water boils the more surprised she will be and the quicker you will make your sale and profit. It stands to reason that the smaller the amount of water you use the quicker it will boil."

In the same instruction notice the statement is made that "the device will heat water quicker than gas". This is typical of the vague and misleading statements made by many of these manufacturers and much could be said of these claims of alleged high efficiency. From the point of view of the Commission's Approvals Laboratory and the Electrical Inspection Department these heaters are objectionable in that they introduce a shock hazard—they consume in most cases a larger amount of current than is safe in an ordinary branch circuit, and they are in many cases constructed in a flimsy manner.

The accompanying illustrations will enable anyone to recognize these heaters, and it is hoped that anyone who may be canvassed by agents will report the fact to the nearest Hydro manager or Electrical Inspector and assist the Commission in eliminating these dangerous devices from the Ontario market.

The Photronic Photo-Electric Cell and Some Typical Applications

By M. B. Hastings, Vice-President, Powerlite Devices, Limited, Toronto

(Presented to Association of Municipal Electrical Utilities at Bigwin Inn Muskoka, June 25, 1932.)

LIGHT sensitive material is not at all new to us nor is the principle of the photo-electric cell new. In fact the photo-electric effect upon certain material has been known since 1887 so that really photo-electricity is quite an old art. It is almost safe to say, however, that it is only recently that the photo-electric cell has entered definitely into the commercial field as a useful and reliable piece of apparatus. There are many types of photo-electric cells, all of which, let us assume, have advantages and disadvantages, making one cell preferable to other cells for a definite application. It is not the purpose in this paper to attempt in any way to deal with the general subject of photo-electric cells, but it may be profitable and interesting to discuss briefly the Weston Photronic photo-electric cell which is possibly the latest development in this field of research.

The Weston photo-electric cell, trademarked "PHOTRONIC", is the result of intensive research on the part of the Weston Electrical Instrument Corporation, and consists essentially of a thin metal disc on which there is a film of light sensitive material. The metal disc forms the positive terminal and a metal collector ring, in contact with the light

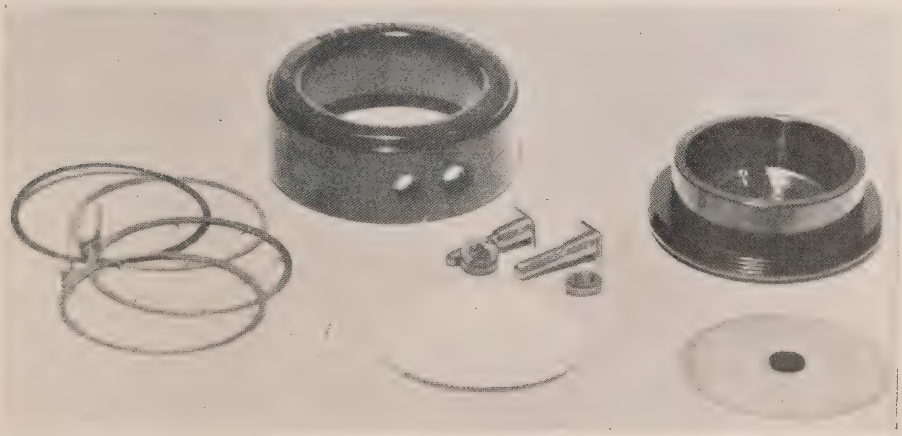


Fig. 1.—Merely a disk, contact fingers and container. Contact rings (at left) tap voltage difference of upper, sensitized surface and lower, unsensitized surface of disk (at right).

sensitive surface, forms the negative terminal. See Fig. 1.

These two terminals are connected to pins of a size and so arranged to plug into an ordinary Radio tube socket. The cell is contained in a moulded bakelite case having a window of ordinary glass or quartz. Ordinary glass is to be used only in the visible regions of the spectrum, while quartz is used for measuring the ultra-violet. There are no separate anode or collector plates, or evacuated space as in the usual form of photo-electric cells, and no liquid is used. The action of the light impinging upon the sensitive surface appears to be entirely electronic and all tests so far made indicate that no chemical or physical change takes place, so that the life of the cell seems to be unlimited. In fact, the cell may be exposed to light of any intensity, even direct sunlight, for any length of time and will continuously produce current in proportion to the light impinged upon it. The cell simply transforms the light energy to electrical energy without itself being in any way deteriorated. In this respect the cell might be compared to a catalyst as used in chemistry, which by its mere presence causes a transformation of another substance. Fatigue effects are slight, and tests indicate that the response remains constant to a high degree of accuracy for an indefinite period of normal use.

The area of the sensitive surface of the cell is approximately 1.7 square inches, so that the output of the average cell when connected to a relatively low external resistance closely approximates 1.4 micro-amperes per foot candle of illumination, or 120 micro-amperes per lumen when the light is uniformly distributed over the sensitive surface. A very interesting and useful property of the Weston Photronic photoelectric cell is, that while it is desirable to distribute the light uniformly over the entire disc, the current output per lumen is almost entirely independent of the area of the disc exposed, that is, a lumen of luminous flux concentrated on a surface of approximately ¾ in. in diameter will result in practically the same micro-ampere output as a lumen uniformly distributed over the entire area. This may be explained by the fact that the resistance of the unexposed portion is so high relative to the exposed portion that the shunting effect is negligible. A similar effect results when the cells are connected in parallel. The individual cells act as if they were independent, each supplying its quota of current proportional to the illumination incident upon it, and if, for example, the illumination of one cell is zero, it may be removed from the circuit with a negligible effect upon the total current output.

This feature permits two or more cells to be used in different places, or directed in different directions to obtain average intensities of illumination. Or the cells may be grouped in one plane in order to collect sufficient light from a low source of light in order to operate sensitive relays. This is important in many industrial applications where the source of light, for reasons, has to to be of a definite character.

Most so called "Electric Eyes" are not at all a match to the human eye so far as color response is concerned,

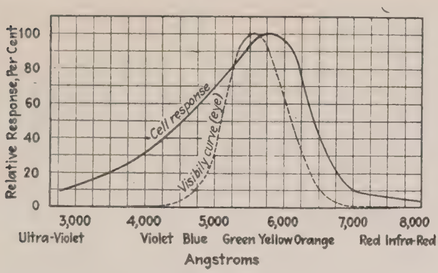


Fig. 2.—Cell responds like human eye. Simple filters can render response almost exactly identical with that of eye because cell is more sensitive in red and blue regions.

but the Weston Photronic photo-electric cell now makes such a match possible. The spectral (color) response of the cell is comparable to that of the human eye and it will be noted that while the curves peak at slightly different values, the cell shows greater sensitivity than the eye in both the blue and red regions. See Fig. 2.

This makes possible the use of a simple filter to mould the cell response to close equality with that of the human eye. Even without a filter this cell is the closest approach to the human eye yet known.

Applications of the Photronic photo-electric cell may be divided into two classes, Direct and Indirect.

Direct Applications:

A direct application would be where the cell is connected direct to a milliammeter and its readings are proportional to the light impinged upon it.

1. One of its most important applications is to improve illumination. Poor quality and low levels of illumination have been ascribed as the direct cause of impaired eyesight, and the chief contributing factor in most of the accidents occurring in industrial plants. While it is common practice to specify minimum illumination intensities, it is rather the exception to make subsequent periodic surveys to determine if the proper illumination condition continues to exist. The reason is obvious when

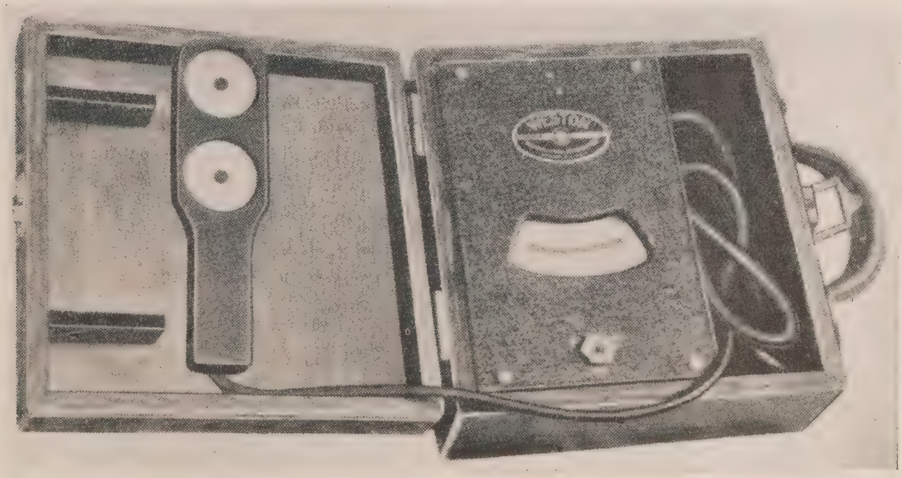


Fig. 3.—Left—Two cells in parallel operate portable micro-ammeter with range of scale from 0.2 to 250 footcandles.

we realize that illumination measuring instruments in general are cumbersome, expensive, difficult to use and by the very nature of their makeup discourage their use. We are all familiar with such apparatus and know too well that even experienced observers will disagree as to the true values. With the Photronic photo-electric cell connected to a micro-ammeter and suitably calibrated, a direct indication of the value of illumination can be obtained anywhere in an instant. See Fig. 3.

There can be little difference of opinion because the reading is as simple as that of an ordinary voltmeter and confidence is inspired rather than doubt.

2. From a health standpoint it is obvious proper lighting conditions are just as important as proper atmospheric conditions. While admittedly illumination standards have improved tremendously in recent years, there are still thousands of cases silently imploring aid. This photo-electric cell will undoubtedly bring about higher levels of illumination which oculists realize is as significant as eye glasses in correcting and preserving the vision of their patients.

3. Another direct application is in the measurement of ultra-violet rays. It has been most difficult, up to the present, to obtain a measurement of the ultra-violet rays, and with the introduction of vitamin D into food products, this measurement has become one of great importance. Previous to the use of the Photronic photo-electric cell the effect of ultra-violet could only be known after approximately 6 weeks of experimenting with mice, etc., in the laboratory. The cell used for this purpose is equipped with a quartz window. The reading is taken with the quartz window, which would indicate the total emission from the ultra-violet source, a second reading would be taken by holding an ordinary clear piece of glass in front of the quartz windows, the latter reading would consist of the total emission minus the ultra-violet, the difference between the two would be the amount of ultra-violet delivered.

4. The Photronic photo-electric cell permits us to enter an entirely new field, that of color matching in its various phases, the automatic control of processes where color is the deciding factor is effected by the use of two cells connected as in Fig. 4.

The equipment is automatically controlled when the color of the product matches the predetermined standard color.

5. The cell permits the accurate measurement of the uniformity of

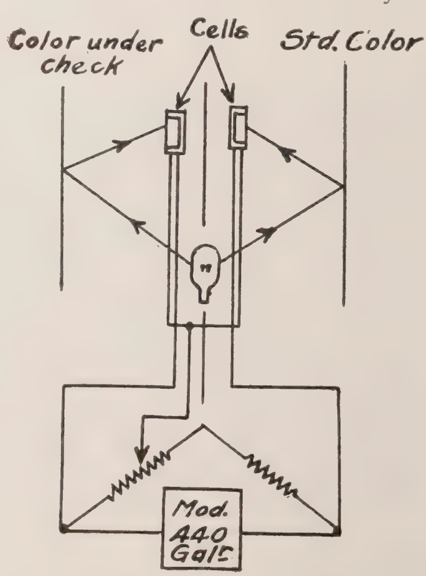


Fig. 4.—Color Matching.

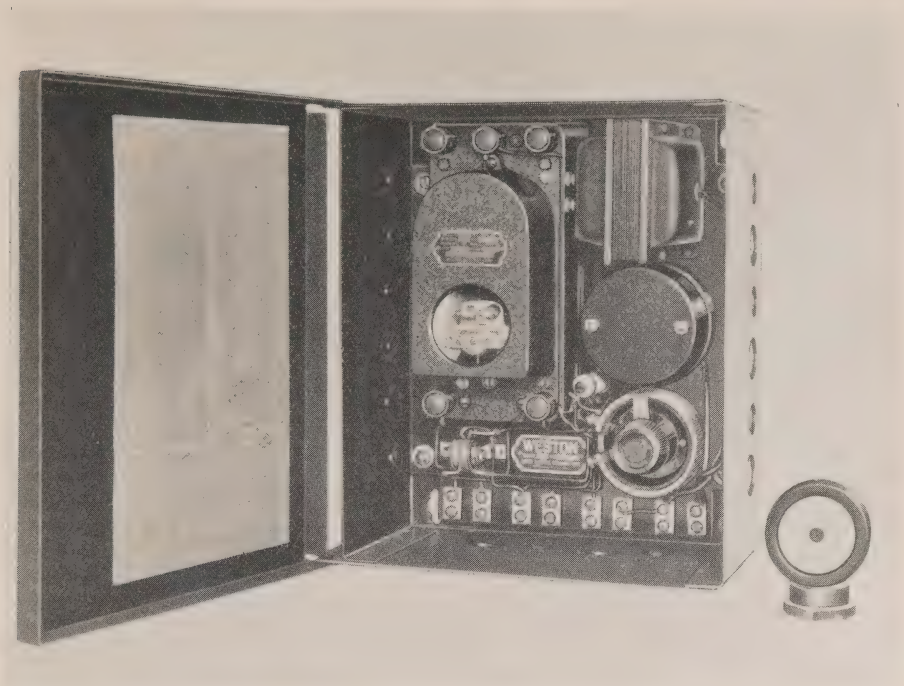


Fig. 5.—Industrial processes controlled by light beam. Speed of cell permits counting or control of operations up to 200 per minute. Similar relay adaptations available for control of outdoor illumination circuits.

reflection value of mirrors, a simple application which, in the past, has been most difficult.

6. Thicknesses of paper can, in many cases, be measured more accurately by the amount of light transmitted, than by the standard method of micrometer measurement.

Indirect Applications:

Indirect applications would include all applications where the cell is connected to a suitable Weston relay which, in turn, operates a secondary relay from which any desired capacity can be controlled. See Fig. 5.

Simple applications of the cell are counting, in its many phases, opening doors, burglar alarms, etc., etc., by either interruption or projection of light on the cell. The speed of the cell easily permits counting or control of equipment up to 200 operations per minute, in fact, it is safe to say it is at present limited only by the speed of the mechanical or electrical apparatus it controls.

1. One of the most interesting indirect applications is the control of illumination.

For example, street lights have long been controlled by time switches, and it was only natural that a time switch with an astronomical dial should be developed to follow the variations in the length of days. It is no reflection on the time switch to say that it is not the real answer for this particular

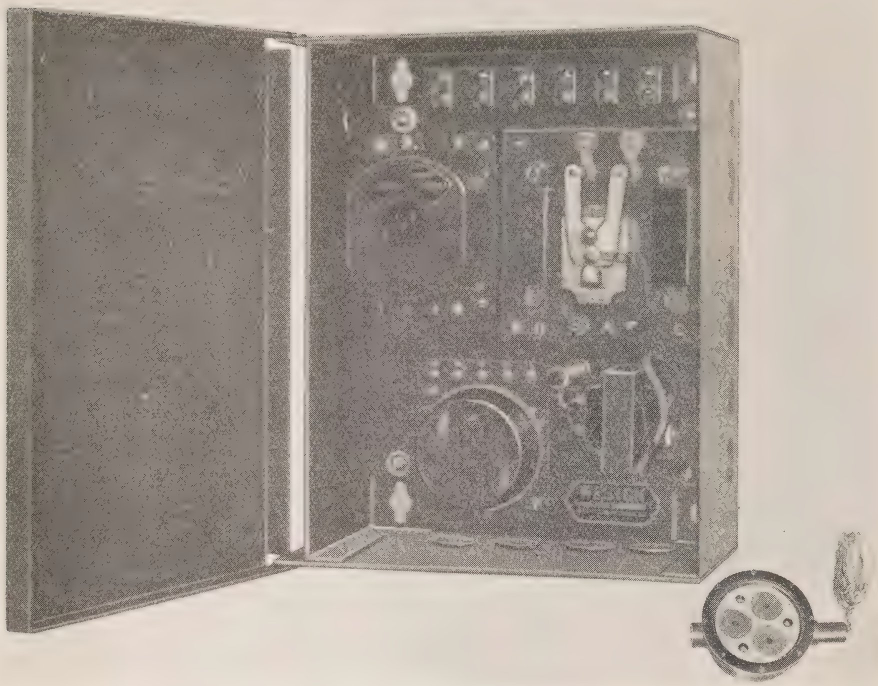


Fig. 6.—Illumination Control.

problem. For even with astronomical clocks, no allowance is made for dark or stormy weather. The electric eye, on the other hand, constantly watches the light intensity and when it falls below the value for which it is set, it passes the information on to the relays and the lights are turned on automatically. The equipment for this consists of but two parts, first, the light collector, and second the relay cabinet. See Fig. 6.

The light collector is the device containing the Photronic photo-electric cells which is mounted on the roof facing the north sky or in the room, the illumination of which is to be controlled.

The relay cabinet is a steel box with standard steel conduit knockout and contains all the relays necessary to control a circuit of 3,000 watts at 110 volts. The sensitive relay has its contacts adjusted to operate at a light level of 5 foot candles minimum. A time delay relay is in the circuit between the sensitive relay and power relay, so that the contacts will not close when clouds pass over the sun and cause the lights to flash on and off. This time delay relay has a time element of about one minute, which is ample to take care of the high fluctuations in light intensity which occur during the hours of daylight.

The resistance of the leads between the light collector and relay cabinet does not affect the accurate operation of the equipment and permits the light collector to be located on the

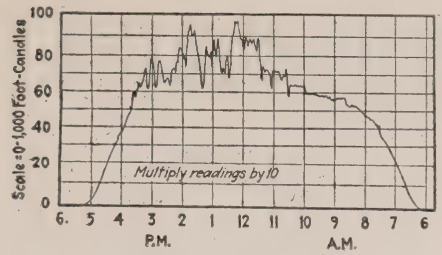


Fig. 7.—North sky on clear November day.

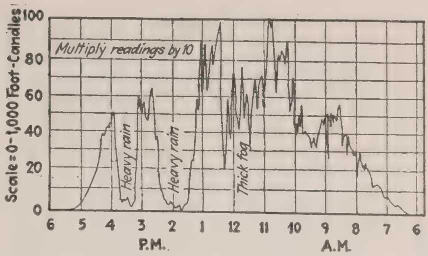


Fig. 8.—North sky on foggy and rainy November day.

roof of the building, and the relay cabinet to be located near the circuits which are to be controlled.

The relay cabinet illustrated is not moisture proof, and should be located inside or in a position where it is not subjected to the elements.

Above are shown Figures 7 and 8 and it is interesting to note that the foot candles at twilight in this longitude on an ordinary day drops from 30 to zero in approximately 15 minutes. The variations in illumination obtained on a rainy day are striking. At 12.17 p.m., the foot candles measured 200, less than 10 minutes later they had increased to 1,000 and at 1.40 p.m., during a heavy downpour the illumination dropped to 8 foot candles.

New applications for all types of photo-electric cells are appearing daily, and it is safe to predict this simple apparatus will be one of the most appreciated developments of recent times.

Surge Absorbers

By G. A. Brace, Sales Manager, Ferranti Electric Limited, Toronto.

(Presented to Association of Municipal Electrical Utilities at Bigwin Inn, Muskoka, June 24, 1932.)

MOST of us have been accustomed to thinking of lightning protection in terms of lightning arresters, and we must revise a lot of our ideas if we are to understand the operation of the surge absorber. It is essential, therefore, to first show the fundamental differences between the two types of protection.

Many names are misnomers, but they have come into common use and it is difficult to change them. The lightning arrester for instance does not arrest the surge on the line, but it is intended to divert it to ground. Similarly, the name surge absorber does not correctly convey the primary function of this apparatus. While the surge absorber does absorb part of the energy of the surge, its main function is to slope off the wavefront before the surge reaches the apparatus. It might more appropriately be called a surge leveller.

The surge absorber is connected in series with the lead from the transmission line to the transformer or other apparatus t be protected, that is, to get to the tr n former the surge must go through the absorber; of course for three-phase transformers there must be a surge absorber in each lead or three surge absorbers for the bank. Thus, the surge absorber must continually carry the current taken by the winding of the transformer which is being protected. This explains why the surge absorbers are rated in amperes and the proper rating must be determined before the surge absorber is purchased or installed.

The case of the surge absorber is grounded, and as the windings are in series with the line, then the windings must be fully insulated from the case, and usually this fixes the voltage rating of the surge absorber to be used. There is another determining factor, however, which is the flashover voltage of the insulators on the transmission line.

While the case and dissipators of the surge absorber are grounded, the winding itself is not grounded at any time. This, of course, is one of the fundamental differences between the surge absorber and the discharge type of arrester, which grounds the line under surge conditions to carry the surge away to ground. Thus, with the surge absorber there is no possibility of a service interruption due to a power arc follow-up.

The surge absorber case or tank must be effectively grounded as this has an important bearing on the capacitance feature of the absorber design. However, the effectiveness of the Ferranti surge absorber is practically independent of the ground resistance. With a ground resistance up to 1,000 ohms the absorption of the surge will not vary more than approximately 5 per cent. from the value it would have when using a dead ground.

The effect of resistance in the

ground lead of the absorber is shown in Fig. 1. This covers one particular case and the curve will vary slightly but not materially for different conditions. The percentage absorption in standard surge absorbers will lie between 70 and 95 per cent. with an average value of approximately 85 per cent., leaving only 15 per cent. of the stress effective in any part of the winding. Absorption of the surge absorber refers to the reduction in voltage under surge conditions across the end sections of the transformer winding, as compared with the stress which would be impressed on the same end sections with no surge absorber in the circuit. Thus it is seen that within reasonable limits the resistance of the ground and ground lead has practically no bearing on the effectiveness of the protection.

The surge absorber is therefore particularly adapted for use in rocky or gravel country where the ground resistance is high. A distribution line may be built with the most modern construction and under the best supervision, but often it is impossible to get a good ground or to keep it. Constant inspection is required and this also costs money. These troubles are eliminated when the surge absorber is used.

The standard type of surge absorber is not designed to reduce the amplitude of the surge, that is, it doesn't necessarily reduce its maximum voltage, although there is considerable reduction with short waves having

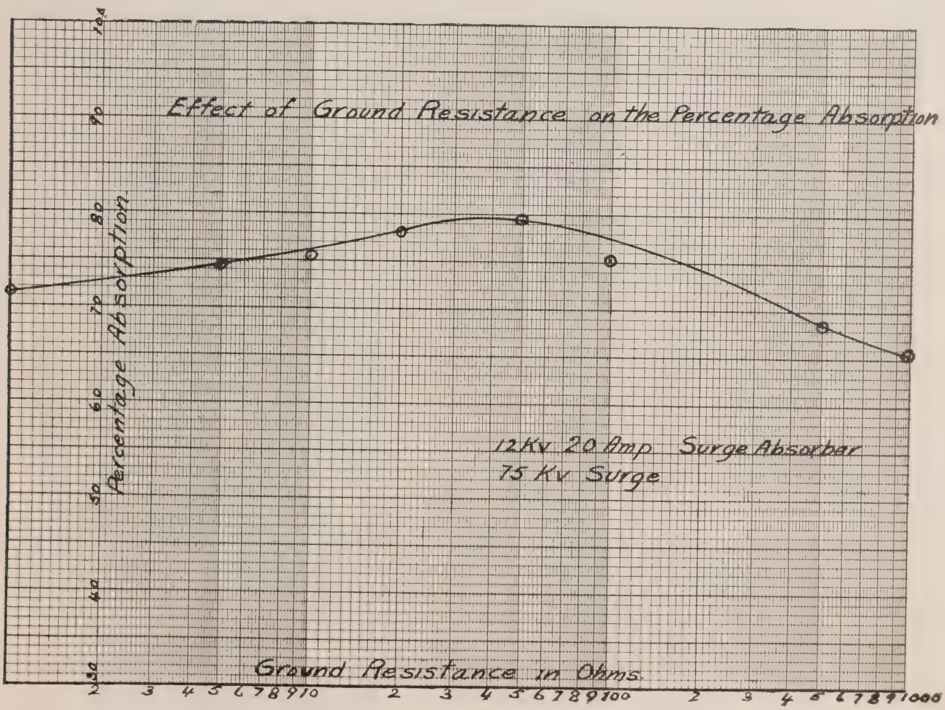


Fig. 1.—Effect of Ground Resistance on the Percentage Absorption of the Surge Absorber.

very steep fronts. The primary function of the surge absorber is to slope off the wavefront, and as we shall see later, this is essential for the protection of transformers and inductive equipment. Thus the standard surge absorber is not intended for the protection of transmission lines or cables where the flashover or breakdown depend only on the amplitude and duration of the wave. The lower factors of safety of motors and generators necessitate some reduction in amplitude as well as the sloping of the wavefront and special surge absorbers are built for this purpose which are more expensive than the standard. Surge absorbers could be built and have been built to protect cables, but the amplitude reduction required is so great that they are usually not economical.

The surge absorber consists essentially of a highly insulated coil without any iron core. This coil is connected in series with the lead from the line to the transformer. The coil is magnetically coupled with high resistance dissipators which also act as condensers. The dissipators are all connected together and definitely grounded to the enclosing tank and to the ground wire. The arrangement is shown diagramatically in Fig. 2. A Type "CC" 50 ampere 12,000 volt single-phase surge absorber is shown in Fig. 3, and the coils are wound with dissipators which are cylindrical

Fig. 3.—Coils Wound with Dissipators. Type "CC", 50 ampere, 12,000 volt, single-phase Ferranti Surge Absorber.

in shape. On the left hand side you can see the connection to the dissipators which is grounded to the tank. A phantom view of a 250 ampere 22,000 volt surge absorber is shown in Fig. 4. This is one of a bank supplied to the Kitchener Public Utilities Commission for use on 13,200 volt wood pole lines. In this type the

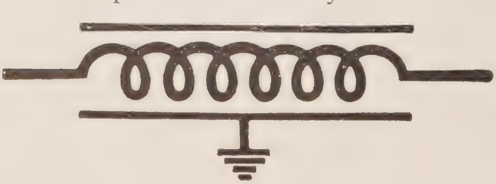


Fig. 2.—Equivalent Circuit of a Surge Absorber.

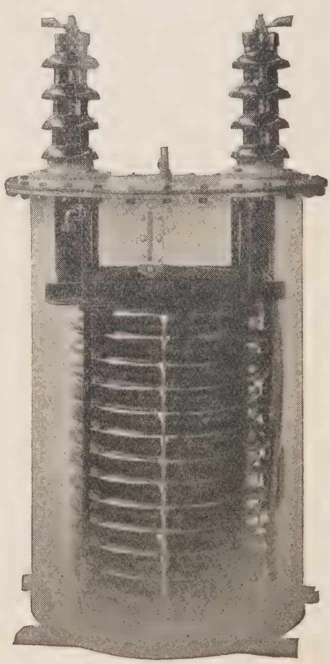


Fig. 4

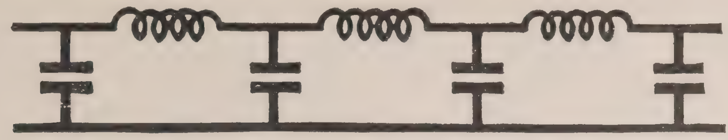


Fig. 5.—The Inductance of the Coils with the Distributed Capacity of the Surge Absorber Form a Filter Circuit.

dissipators are circular in shape and interleaved between the disc coils.

At high frequencies the dissipators have currents induced in them from the coil just as the secondary of a transformer has from its primary. The surge absorber is designed to have a high electro-static capacity between the coils and the dissipators. With the dissipators grounded they act as the ground plate of a very large condenser and this capacity acts as a shunt to the series inductance of the coil; thus you have a high frequency or steep wavefront filter circuit just like that in the "B" eliminator of your radio set, but on a much greater scale. This is shown diagramatically in Fig. 5. With this filter we can economically slope off the wavefront sufficiently for the protection of the inductive apparatus.

In solving any problem it is essential to understand exactly what is involved, and thus it is necessary to give a little study to lightning waves and their effect on the voltage distribution of the surge in a transformer.

When a cloud becomes charged the potential is built up to high values and a static field is set up between the cloud and the earth and the cloud and the wire as shown in Fig. 6. When the voltage between the cloud and the earth becomes great enough, the cloud discharges to ground in the lightning flash with which we are all familiar. This discharge is usually exceedingly fast and the charge on the line is released and begins to travel in both directions along the line.

The length of line that becomes charged by a cloud is not very great and even in extreme cases doesn't exceed 25 miles, but the travelling wave set up may go a long way and cause damage many miles away. This is something like a tidal wave in the ocean, where you have a disturbance in the floor of the ocean in the Caribbean Sea and set up a tidal wave which causes tremendous damage in Newfoundland, several thousand miles away.

The usual type of travelling wave set-up is shown in Fig. 7, and two waves of this type start in opposite directions from the propagating point. Each wave is similar to a tidal wave in the ocean or to a tidal bore steadily advancing but gradually decreasing as its energy is expended.

These induced lightning waves

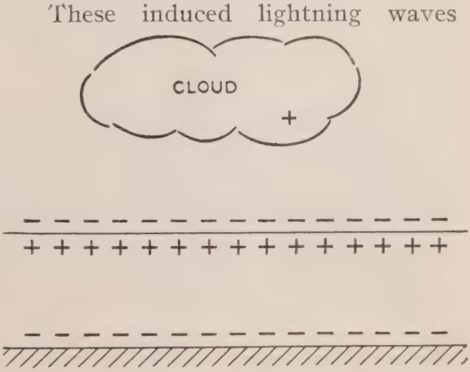


Fig. 6.—A Positive Charge is Assumed on the Cloud.

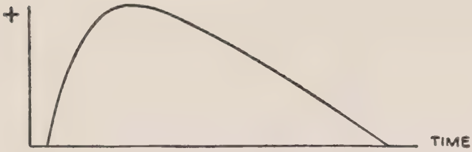


Fig. 7.—This Shape of Wave is the Most Usual Type Found in Practice.

travel at a tremendous speed, roughly about a thousand feet in one one-millionth of a second, or approximately 670 million miles an hour. Such a wave would travel more than seven times around the world at its equator in one second.

Field tests of actual lightning waves have shown considerable variation in the shapes, and the shape will depend on the dimensions of the line, the insulators and the attenuation of the wave. When the wave starts out it may have a steep front such as in Fig. 8, where it reaches its maximum value in one-half micro-second from the instant it starts to rise. At the end of five miles of travel the shape of the wave may be changed to that of Fig. 9 and take 5 micro-seconds to reach its maximum; now the wave-front extends for a mile long along the transmission line while the whole wave shown in Fig. 9 would extend for over 20 miles. This change in shape is mostly due to the corona loss in the line, especially when the voltage in the surge is above the corona voltage point.

The maximum voltage of the lightning wave at the point where it starts, will depend on the height of the line and the distance of the cloud from the line, but the voltage of the travelling wave under surge conditions will be limited by the flashover voltage of the

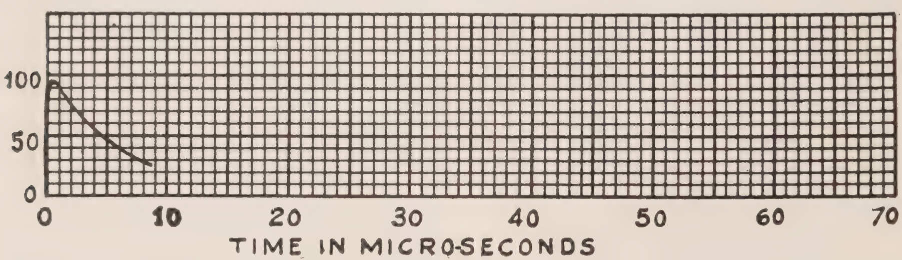


Fig. 8.—Steep Wavefront, High Voltage Surge which reaches its Maximum Value in 0.5 Micro-seconds and takes 5 Micro-seconds to drop to 50 per cent. of its Maximum Value.

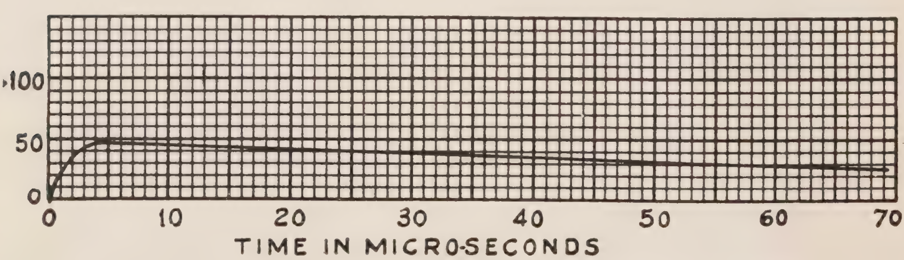


Fig. 9.—A 5 Micro-second Wave, which drops to 50 per cent. of Maximum Value in 70 Micro-seconds.

insulators and the corona loss. With steel towers or with grounded steel pins the flashover voltage of the insulators will be the governing factor and the maximum surge voltage possible will be 1.2 to 2.5 times the 60 cycle dry flash over voltage of the line insulators. With wood pole construction the amplitude of the surge is reduced by the corona loss and this reduction is great with the smaller wires and closer spacing of the low voltage lines.

The surge travels along the line until it comes to some change in conditions, called a change in line constants, and here part of the wave may be reflected back on its original path, while the other part of the wave goes on. The reflected part will add to the rest of the wave which is still coming in and cause a piling up at that point so that the total height of the wave there is greater than it was originally. This can be shown graphically with water waves, which to a reasonable extent, makes a good analogy for lightning surges.

In our demonstration we have a trough whose cross section is uniform for part of its length and this trough represents a transmission line of medium surge impedance. At one end it abruptly changes into a narrow trough which represents a transformer which has the effect of a line of high surge impedance. This surge impedance is a combination of inductance and capacity and has quite different effects from what we normally think in connection with impedance. We now have a transmission line with a transformer connected to the end of it and corresponding to one phase of a three-phase star-connected transformer with isolated neutral. The trough is about one-half full of water and the area of its cross section is a measure of its resistance to the flow of the water and therefore represents the impedance of the line.

Let us start a wave at one end of the trough. It travels rapidly and with little attenuation until it reaches the narrow section which corresponds to the terminals of the transformer. At this point part of the wave is reflected and it travels right back along the transmission line. Part of the wave passes into the transformer and sets up severe oscillations as you can see in this section. The height of the wave represents the maximum value of the voltage in the lightning surge, and at the transformer terminals the voltage becomes greater because the reflected wave adds to the incoming wave. The voltage inside the transformer is piled up at different points due to the oscillations; thus extremely high stresses are impressed on the insulation at different points throughout the windings as the oscillations continue.

Let us see what happens in a real transformer during a lightning surge. At the moment of impact of the surge, the voltage of the surge is not distributed uniformly throughout the windings as it would be at 25 cycles, but is concentrated in certain sections. This sets up oscillations in the windings as we saw in the demonstration. The disturbances in the water in the transformer section of the trough correspond to the severity of the concentration of the voltage stresses in a real transformer, and such concentration of stresses in a trans-

former depends on the relative capacities from the coil sections to ground and between sections, and also depends on the steepness of the wavefront of the surge. For example, the wave in Fig. 8 will give a greater voltage across the end sections of the windings than that in Fig. 9. If the maximum voltage peak in the lightning surge travelling along the line is 100,000 volts, then if the shape of the wavefront is like Fig. 8, at the moment of impact there will be about 55,000 volts impressed on the one section of the winding nearest the transmission line. If the wavefront had a shape like Fig. 9 there would still be about 27,000 volts impressed at that end section. The length of the tail has very little effect on the distribution of the stress throughout the winding. As the oscillation continues these stresses are impressed on different points throughout the winding.

Of course the transformer designer tries to make his relative capacities as small a ratio as possible in order to prevent this concentration of voltage either between sections or turns and all good transformers are designed with this end in view. Unfortunately, there are practical reasons why very little can be accomplished in this way. Good results have been obtained by connecting condensers across the sections as in the non-resonating transformer, but the cost and increased size of the transformer make it uneconomical except in very large, high-voltage units.

It is possible to design and build transformers with very high insulation values to ground sufficient to stand up under practically all conditions of stresses to ground, but it is not possible to apply sufficient insulation between turns and sections to withstand these great concentrations of voltage which take place under surge conditions. The more insulation you try to apply between turns and sections, the greater the capacitance and the greater this concentration becomes. Hence the designer finds himself in a vicious circle. Long experience with transformers in service has shown that practically all failures due to lightning are between turns or sections and not from the high tension winding to the ground, or to the low winding. In other words, the failures are caused by this concentration of voltage and therefore by the steepness of the wavefront.

These conclusions are confirmed by some interesting tests made at our British factory. The transformer shown in Fig. 10 was a 25 kv-a., 50 cycle, three-phase, 11,000 volt pole-type distribution transformer of standard construction in every respect except that the high tension windings were connected in star so that each phase leg of the transformer could be tested separately. A short transmission line was connected at one end to the terminals of the phase being tested and at the other end to a surge producing generator. Preliminary measurements showed that with the surge being used the sparkover voltage of the line insulators was 230,000 volts. Since these insulators were considerably larger than in normal 11,000 volt practice, correspondingly larger bushings were fitted temporarily to the transformer. The arrangement is shown in Fig. 11 with the transmission line connected to the

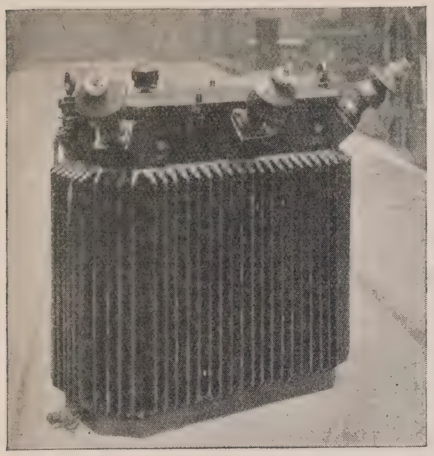


Fig. 10.—Standard 25 kv-a., 11,000 volt Distribution Transformer used in the Tests.

middle phase (that is, leg "B") of the transformer.

Many surges were impressed on the windings with and without the transformer energized from the low tension side and observations made. Finally 500 additional surges were sent into this leg of the transformer to insure a main breakdown which was found to be at the top of the line coil between turns and layers underneath the yoke. A photograph of the result is shown in Fig. 12. Failures were found between turns and between layers at various other places and at the bottom of the coil of this leg there were a number of minor breakdowns between turns and layers similar to that shown in Fig. 13.

I have not attempted to go into the tests in detail, but the results prove the following conclusions;

(1) The windings of a standard distribution transformer will not withstand surges such as they may receive under normal operating conditions.

(2) Although surges were sent into the transformer when it was connected to a 50 cycle power supply and when the windings had been definitely damaged by the surge, no dynamic arc resulted and no fault power current flowed.

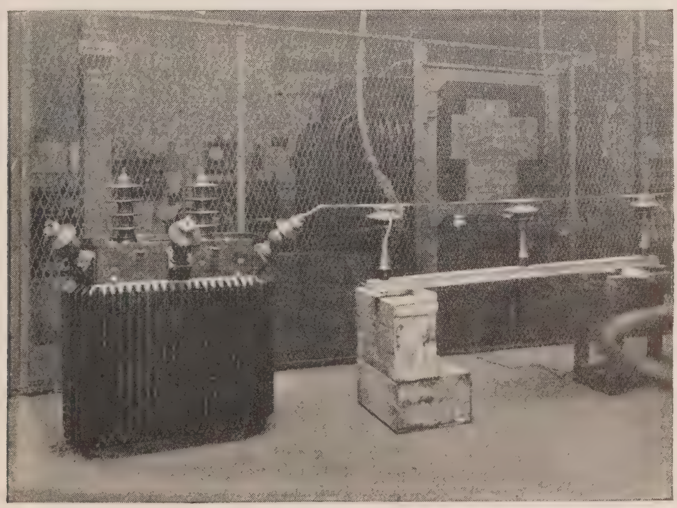


Fig. 11.—Arrangement of Transmission Line and Transformer showing Artificial Lightning Surge Flashing over Line Insulator.

Fig. 12.—View of Transformer Windings after the Surge tests, showing the Damage Done to the Unprotected Phase.

(3) The breakdowns within the windings due to surges are clean and show little signs of charring so that after the surge is passed there is still considerable dielectric strength left in the insulation.

(4) It is possible for the winding insulation to be damaged in numerous places by surges without the damage being apparent from outside or from normal 50 cycle operation.

(5) Over-potential tests or tests of magnetizing current at working voltage show absolutely no change after the windings have been damaged by surges.

(6) Although surge failures do

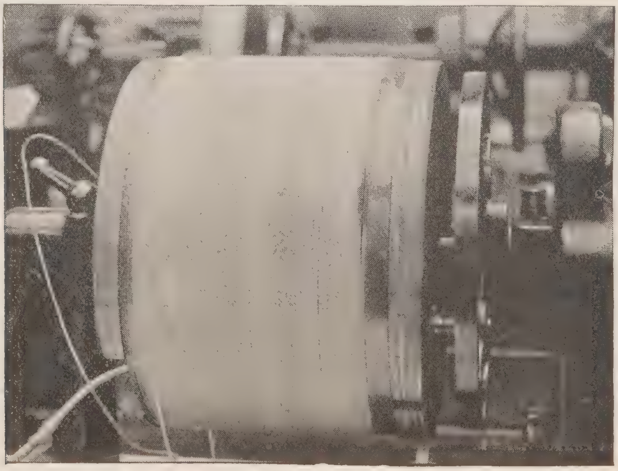


Fig. 13.—Typical Breakdown between Turns of the Coil Due to Surges.

not show up at the time, yet they certainly form weak links in the insulation and will be the seat of breakdowns at some later date.

(7) Since the maximum surge that may appear on the line is limited only by the flashover voltage of the line insulators and the corona loss, raising this voltage definitely throws more stress on the transformer and involves a greater risk of breakdown.

(8) If it is desired to increase the flashover voltage of the line insulators then either the transformer insulation should be increased in proportion or some means of protecting the transformer should be adopted.

(9) None of the transformer breakdowns occur between windings and ground or between high tension and low tension windings. Such breakdowns would be due to the amplitude of the surge so that it may be considered that the amplitude of the surge is not important as regards transformer insulation. Protective devices such as the discharge arresters which operate on the amplitude of a surge are therefore inherently wrong in principle for transformer protection.

(10) All of the numerous breakdowns occurred between turns and between layers. Stresses between turns and between layers are due to the steepness of the wavefront and not to the amplitude of the surge. The important point in transformer protection is therefore to reduce the steepness of the wavefront.

Similar tests were made with leg "C" of the transformer, but with the standard type of Ferranti surge absorber connected between the transmission line and the transformer. Many surges were sent into the windings and after the coils were dismantled and completely unwound no sign of damage was found after careful examination turn by turn. These tests show that the surge absorber completely protects the transformer. They also show that it is dangerous to assume that a transformer has been undamaged by surges because no evidence of failure can be determined by external inspection of the windings, or by over-potential tests or measurements of the magnetizing current. A transformer may be badly damaged during a lightning storm, but continue in service for several weeks. By this time the storm is forgotten and the initial failure is blamed on some other apparent cause. Similar tests with a 60,000 kv-a., 132,000 volt, three-phase transformer using one million volt surges proved the same conclusions.

Now let us turn to the water wave again and see what happens when a cable is placed in the circuit. The expanded section in the trough represents the capacity of the cable and thus we now have a cable between the transmission line and the transformer. You will notice how the height of the wave drops after it reaches the cable, but you also notice how it travels to and fro in the cable. These waves travelling back and forth in the cable build up to increasingly higher values and help to break it down. You will also notice the oscillations in the transformer. This demonstration shows that the cable

does not protect the transformer from having dangerous oscillating waves set up in it, although this has previously been the accepted theory.

A cable is a distributed capacity while the transmission line is equivalent to distributed inductance and capacity, but a choke coil is a lump inductance with practically no capacity and can be represented in our water analogy by a short narrow section in front of the transformer terminals. The ordinary choke coil has a very small resistance and small inductance (from 10 to 40 microhenries under surge conditions comparing with 300 to 500 for the surge absorber). While the impedance of the choke coil is less than that of the transformer at normal frequencies its impedance goes up with the frequency, while that of the transformer does not. Thus, under surge conditions the choke coil has a higher impedance than the transformer and may be represented by a narrower section in our trough than that of the transformer.

The wave again comes down the transmission line and as it strikes the choke coil there is considerable reflection and violent oscillations inside the transformer which may be worse than if no choke coil were present at all.

Of course it is well known that a choke coil of very large impedance connected in series with the line may materially flatten the wavefront of an incoming surge. Also, a condenser connected between the line and ground may give good protection. The serious objection to both is that they are liable to enter into combination with capacity or inductance in the adjacent circuit such as a transformer bushing or short length of line and form a local oscillatory circuit. Excess voltages may be produced under certain conditions which will make the effect of the choke coil or the capacity worse than if it had been omitted altogether.

The surge absorber may be looked upon as including the advantages of a large inductance and capacity. The disadvantages are obviated by making the combination non-resonating through the large losses set up in the dissipators.

Returning to our water trough, we will put a restricted section in the expanded region which previously represented the cable, so that now we have the transmission line, then an expanded portion, then a narrow section, another expanded portion and finally the transformer. The expanded sections are equal in area and we now have a surge absorber with a large capacity which is the same at both ends and with a medium inductance. This is the type of surge absorber used for the heavier currents. Now the wave comes along the transmission line and you will notice the great reduction in the oscillation in the transformer. Having now prevented the concentration of voltage in certain sections of the transformer winding, we have stopped the oscillations and the dangerous stresses between turns or sections.

Under surge conditions the I^2R and eddy current losses induced in the dissipators are very large as the latter are made of silicon steel or other high resistance metal. For example, with a 200 ampere, 15,000 volt absorber the losses under surge

conditions will be approximately 500,000 watts. Losses of this magnitude would soon burn up the absorber if they lasted for any length of time. Fortunately the surge only exists for a few micro-seconds and the absorber will stand these losses without undue heating. These losses help to reduce the amplitude of the surge by preventing the inductance of the coil and the capacity of the transformer from resonating at the terminals of the transformer. They also dissipate some of the energy of the wave and thus help to modify the wavefront.

Under surge conditions at the instant of impact the inductance of the surge absorber acts as a very large impedance. This holds up the wave and gives the condenser a chance to get charged up. Thus the energy is stored up in the capacity and the wave shape is changed as it slowly discharges into the transformer. Unfortunately, we cannot show the change in wave shape with our water wave, but we can show that with the surge absorber the oscillations inside the transformer are materially reduced, although they were great when capacity alone was used, that is, when the transformer was protected by the cable, or when the choke coil was used.

Now let us consider a transformer protected by a discharge-type arrester. Returning to our demonstration, we have a section at the back of the trough where the transformer is connected to the transmission line and this section is cut away so that any wave which is twice the normal height of the water will splash over and be carried out of the trough. You can see the reflection which takes place at the transformer or lightning arrester terminals and you can see the wave that penetrates into the transformer. You still have violent oscillations in the transformer in spite of the reduction in amplitude. This shows clearly that though you may cut off the top part of the surge, yet the part that comes into the transformer still has its steep wavefront and will be concentrated between certain sections or between certain turns, and this stress is still sufficient in many cases to break down the windings of the best designed transformers.

This explains why protection from discharge-type arresters is by no means 100 per cent. A technical news bulletin issued by the United States Bureau of Standards in July, 1929, showed that 91 per cent. of the breakdowns in transformers reported occurred in transformers protected by lightning arresters. It doesn't necessarily mean that the transformer protected by the discharge type of arrester will go out of service the first time its windings are punctured, as our tests previously described have shown that a transformer may stay in service for quite a while after it has been broken down until finally successive surges actually put the transformer out of service. This clearly shows that relating the voltage stress limited by the lightning arrester to the usual high potential test of the transformer is quite incorrect, as the high potential test is made at low frequency and the stress is distributed over the windings; while the voltage impressed by the lightning surge may be practically all concentrated on the first few turns.

We have seen that the main func-

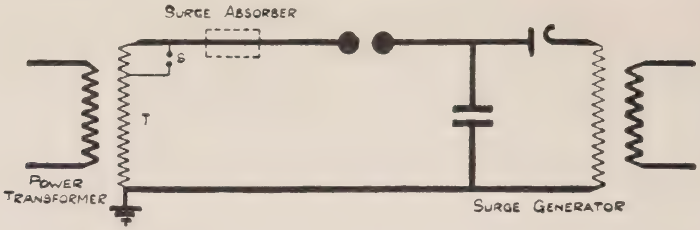
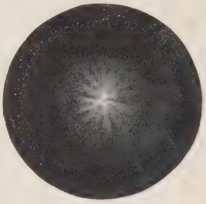


Fig. 14.—Diagram of Connections of the Testing Circuit.

tion of the surge absorber is to prevent the concentration of a large portion of the stress between sections or between turns and to distribute it uniformly across the winding. From this we can obtain a measure of the absorption of the surge absorber by determining the reduction in voltage

Fig. 15.—Klydonograph Record of the Surge Absorber across the End Turns of a Transformer with the Surge Absorber in the Circuit.

(Below).—Klydonograph Record corresponding to Fig. 15 without the Surge Absorber in the Circuit.



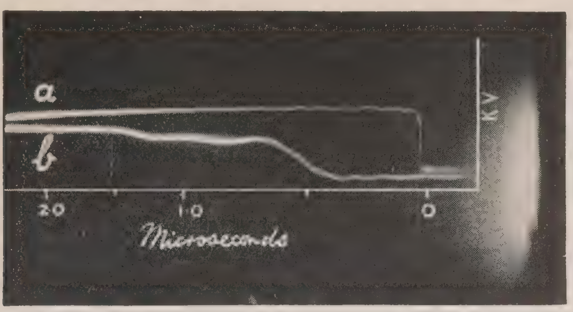


Fig. 16.—Cathode Ray Oscillograms showing a High Voltage surge before and after passing through the Surge Absorber.

across the end sections of the transformer winding when the surge absorber is used. The testing circuit is as shown in Fig. 14. By sending the surge into the absorber without any intervening transmission line the surge is as steep and powerful as it can be, while the capacity of the surge generator is sufficient to store much more energy than would be contained in the most severe surge that present knowledge considers possible. If the voltage across the end turns of the transformer as indicated by the spark gap S, is V_o without the absorber in the circuit and V_s with the absorber in the circuit, the effectiveness of the absorber may be expressed in terms of per centage absorption as follows;

$$\text{Per cent. absorption} = 100\left(1 - \frac{V_s}{V_o}\right)$$

As stated before, the percentage absorption for standard surge absorbers will lie between 70 and 95 per cent. with an average value of approximately 85 per cent., leaving only 15 per cent. of the stress on any part of the winding as compared with what it would have been without the surge absorber.

A more impressive visual indication of the effect of the surge absorber is obtained by connecting the klydonograph or surge voltage recorder across the end turn instead of the sphere spark gap S. Fig. 15 shows typical records obtained in this way of the voltage across the end turns with and without the absorber in the circuit. Tests made with the Cathode Ray Oscillograph showing a high voltage surge before and after passing through the surge absorber are shown in Fig. 16. These tests show graphically, how the wavefront is sloped off by the surge absorber.

The most valuable and convincing proof of the effectiveness of the surge absorber is given by accumulative operating experience. A single report of a particular installation that no trouble has been experienced since surge absorbers were installed is rather indefinite evidence, but the large number of such reports which have already been received from all parts of the world, and under all kinds of operating conditions, become very positive and definite evidence. Ferranti surge absorbers have proved themselves in those districts where heavy lightning storms are most frequently experienced, as is evidenced by repeat orders from such

countries as East India, Burma, Siam and East Indies. Even under these world's worst conditions there is no instance on record of a surge absorber failing to give complete protection where it was properly applied. Ferranti surge absorbers have already shown good results in Canada, where they have been installed in nearly all provinces.

Water Versus Steam Power in the United States and Canada

By H. E. M. Kensit

IN *World Power* of February, 1932, there was a most interesting editorial on Water versus Steam Power. It gave a very clear digest of the case for steam power as presented by Mr. George A. Orrok at the International Conference on Bituminous Coal at Pittsburg. Mr. Orrok's view was that in economy steam power now competes with and often surpasses water power. Mr. Orrok is a recognized authority on this subject; his figures are in accord with the known facts, and are confirmed by the comparative progressive position of these sources of power in the United States.

The conditions are, however, so widely different in the United States and Canada that it is of both practical and academic interest to review them. The northern portion of the United States and the southern portion of Canada are under very similar conditions as to topography, climate, and class of population, with only a political boundary-line between them, yet in respect to power resources the situation is practically opposite or reverse. In both countries the great majority of the population and industry are in the eastern half of the continent—in Canada in the great industrial provinces of Ontario and Quebec and to a less extent in the adjoining smaller Maritime Provinces, and in the United States directly south thereof. In the centre of this portion of the United States, almost central and extending across the greater part of the width and far north and south, are vast deposits of high-grade coal—in the portion of Canada that is equivalent to the foregoing both geographically and in area, i.e., the provinces of Ontario and Quebec, there is practically no coal—Ontario has a small deposit of low grade in the far north that has only recently become accessible and has not yet been utilized, and Quebec has none at all. Had these provinces been dependent on imported coal they could never have attained their present considerable industrial development. The comparatively small coal resources of the Maritime Provinces involve deep and expensive mining, and while a certain amount of this reaches portions of the province of Quebec, it has not shown itself capable of competing with water power; the western coal of good grade is 2,000 miles from the Ontario industrial markets and still further from Quebec. The position in respect to

water power in this area is therefore not likely to change.

Returning to the United States, the country is divided nearly east and west by the Mississippi River, and about one-third of the total area lies to the east thereof; as pointed out by the Federal Power Commission, 72 per cent. of the water power resources are west, and nearly 80 per cent. of the power requirements are east, of that river, and, as shown by the United States Government Super-power Committee of 1924, not more than 25 per cent. of the total power requirements of this eastern area can ever be met by water power. In this connection one of the most entertaining addresses the writer ever listened to was that by Dr. George Otis Smith of the U. S. Geological Survey on the situation that would have arisen if what is now the United States had been discovered from the Pacific instead of the Atlantic side; the majority of the great water powers and many other resources are on the Pacific side, and he drew a vivid picture of what the position would now be if the country had been first developed from that side.

The United States as a whole may be termed a fuel power country, not a water power country, for some 67 per cent. of the total power requirements are met by fuel power. This has led to great development of fuel power—the United States possesses many of the largest and most up-to-date fuel power plants in the world, has achieved an average fuel consumption for all public utility power plants in the country in 1931 of 1.55 lb. per kilowatt-hour, and over the past five years fuel plant has increased on the average some 65 per cent. more than water power plant.

In Canada the situation is more than reversed. Nearly 70 per cent. of the water power resources are in the east, where are located the greatest centres of population and industry, and at least 80 per cent. of the total power requirements of the whole Dominion are met by water power, so that Canada is essentially a water power country. Fuel plants are small and the average coal consumption of public utilities is 3 lb. per kilowatt-hour, nearly double that in the United States. As explained above, the great central and industrial provinces of Ontario and Quebec are practically coal-less, but Canada has abundant coal—some in the Maritime Provinces and enormous quantities in Alberta and British Columbia; both these sources are too distant to bear the freight and to compete with water power in Ontario and Quebec, but they are fully used locally. The fuel power stations are in these districts, and in addition there is some fuel reserve to hydro-electric plants and some fuel power in manufacturing plants requiring large quantities of process steam; this fuel power gradually increases, but nevertheless becomes a diminishing percentage of the total power in use.

Canada is still looked upon, and particularly abroad, as mainly an agricultural country, but for a number of years past the value of the production of manufactured goods, with all duplication deducted, has exceeded that from agriculture, and the development of mineral industries is proceeding with equal if not greater rapidity. For the development of

manufactures and mineral resources, power is vital; of water power Canada has already developed over 6,500,000 horsepower, and this only constitutes some 15 per cent. of the resources available from coast to coast.

The more fully the power situation in Canada is examined the clearer it becomes that her future is vitally dependent on continuing development of her water power, not only in the present industrial districts but for the exploitation of the vast mineral resources now disclosed and almost daily further disclosed in the more northern portions of the provinces and throughout the North West Territories.—*World Power.*

Fifty years ago the President of the Midland Association of Gas Managers, Mr. R. O. Patterson of Cheltenham, at the Annual Meeting of the Association in Birmingham, said he believed that in five years' time (if not sooner) they would have had the last of electric lighting for many a long year to come, adding "Nevertheless, we wish it no evil".—

—*The Electrician.*

Congratulations

Congratulations are extended to Mr. Geo. J. Mickler, Manager of the Sales Department of the Commission on behalf of his parents, Mr. and Mrs. J. H. Mickler of Preston, Ont., who celebrated their Golden Wedding Anniversary on June 13th. The occasion was marked by a reunion of all their children and grandchildren.

For Sale

The following transformers are for sale by the Fergus Hydro-Electric System.

Make	*Kv-a.*	*Type*	*Cycle*	*Serial*	*Volts*	*Purchased*
C.G.E.	40	H25	25	66682	2200-2000-1900/550	May, 1918
"	40	"	25	67008	"	Nov., 1918
"	40	"	25	68190	"	Jan., 1919

These transformers were used to supply the plant of Beatty Brothers, Limited, at Fergus, until replaced with larger equipment, due to increased load. They are reported to be in good condition, having been properly cared for and not overloaded.

Fergus Public Utilities Commission,
Fergus, Ontario.

THE

BULLETIN

Published by

HYDRO-ELECTRIC POWER COMMISSION
of Ontario

190 University Ave.
Toronto

Subscription Price $2.00
Per Year

Chairman, The Honourable J. R. Cooke's Letter of Submittal of the Twenty-Fourth Annual Report

TO THE RIGHT HONOURABLE SIR WILLIAM MULOCK, K.C.M.G., P.C., C.J.O., *Administrator of the Government of the Province of Ontario.*

MAY IT PLEASE YOUR HONOUR:

The undersigned has the honour to present to your Honour the Twenty-fourth Annual Report of The Hydro-Electric Power Commission of Ontario for the fiscal year ending October 31, 1931.

This Report covers all of the Commission's activities and also embodies the financial statements for the calendar year 1931, of the municipal electric utilities operating in conjunction with the various systems of the Commission and supplying electrical service to the citizens of the Province.

Dealing, as it does, with a multiplicity of activities relating to several electrical systems obtaining power from thirty-nine hydro-electrical developments operated by the Commission, supplemented by power purchased from other sources, and recording financial and other data relating to the individual local municipal electric utilities, the Annual Report presents a large amount of statistical information, much of which must, of necessity, be of a summary character.

The financial statements, the statistical data and the general information given, however, are so arranged and presented as to give a comprehensive survey of the Commission's operations. Not only does the Report record the progress made during the past year, but it gives, in addition, certain cumulative results for the various periods during which operation has been maintained in the respective municipalities.

At the end of the fiscal year the number of municipalities served in Ontario by the Commission was 721. This number included 27 cities, 93 towns, 263 villages and police villages and 338 townships. With the exception of 12 suburban sections of townships known as voted areas, the townships and 86 of the smaller villages

CONTENTS

Vol. XIX No. 7

July, 1932

are served as parts of 167 rural power districts.

Constructional Activities

The chief constructional activities of the Commission during 1931 comprised the completion to the initial operating stage of the Chats Falls development on the Ottawa River with its associated 220,000-volt step-up transformer station; the placing in service of the second and third units at Alexander power development which serves the Thunder Bay system; improvements and repairs at the Big Chute plant on the Severn River, and at the South Falls plant on the South Muskoka River—two of the plants serving the Georgian Bay system; the building of one new bridge and the reconstruction of a portion of a second in connection with the Queenston-Chippawa development; the completion of work in connection with the concrete envelope around conduit No. 3 at the Ontario Power plant at Niagara; the construction on separate towers of a third circuit of the Hydro 220,000-volt transmission lines, to convey the power to be developed at Chats Falls; the construction of a new 132,000-volt transmission line, 189 miles long between Hunta and Sudbury in Northern Ontario; the addition of two transformer banks at Toronto-Leaside transformer station, also two transformer banks at Toronto-Bridgman transformer station; the completion of transformer stations in Hamilton and near Kingston; the construction of a number of smaller distributing stations on the several systems; the addition of transformer capacity to many transforming and distributing stations, and the construction of about 1,470 miles of primary lines in rural power districts.

The virtual completion of the hydraulic structures of the joint Chats Falls development of the Commission and the Ottawa Valley Power Company, within a period of little more than two years from the commencement of construction is an exceptional achievement. Favourable climatic and stream-flow conditions prevailed during the construction period and greatly facilitated the progress of the work. The ultimate capacity provided for is 280,000 horsepower of which 224,000 horsepower in eight units is at present being installed. The maximum head developed is 58 feet. The dam has a length at the crest line exceeding three miles, but nowhere is of great height. The power house straddles the interprovincial boundary and half the generating units are placed on the Ontario side and half on the Quebec side. Descriptions of both the hydraulic and electrical features of the Chats Falls plant are given in the body of this report.

At Alexander power development

on the Nipigon River, which was placed in operation last year, the second and third units were installed, bringing the capacity up to 54,000 horsepower. Headworks are installed for a fourth unit. The head developed at the site is 60 feet. A description of this development also is given in the body of this Report.

In the Abitibi district of Northern Ontario the Commission has constructed a two-circuit steel-tower transmission line 189 miles long to convey 25-cycle power purchased from the Ontario Power Service Corporation. The power is to be generated at the Abitibi Canyon on the Abitibi River and delivered to the Commission at Hunta some 55 miles from the plant. The Commission's line extends from Hunta, situated some 10 miles west of Cochrane, to Sudbury. The line is designed to operate at 132,000 volts and it is of interest to note that this voltage is the same as that employed in Great Britain for the inter-connecting transmission system there known as the "Grid." At present the line is being operated at 110,000 volts.

Throughout the various systems, changes and increases in transformer and switching equipment are constantly being made. The completion of a 15,000-kv-a. transformer station at Hamilton and the rapid design and construction of a 15,000-kv-a. transformer station at Kingston are worthy of mention. The latter station was needed at short notice to take care of the situation impending by reason of water shortage for the hydro-electric developments of central Ontario.

The consolidation of transmission networks and the tying in of large blocks of power to the Niagara system over long transmission lines brings special problems of an intricate technical character. Special devices are being installed at strategic points to minimize and localize any trouble developing.

The Commission, in connection with its several systems, operates some thirty-nine hydro-electrical developments and is continually improving these as opportunity offers or as necessity arises in order to maintain the plants at the highest possible efficiency. During the past year special repairs were made to the power canal at the Big Chute plant on the Severn River, and at the South Falls development on the South Muskoka River a wood-stave penstock was replaced.

The Commission endeavours to have the surroundings of its various properties attractively laid out and maintained. In connection with the grading, etc., associated with this class of work, it has been able to give some relief to the unemployment situation in the Niagara and Eastern Ontario districts.

At Toronto-Leaside transformer station the addition of two 45,000-kv-a. transformer banks raises the capacity of the station to 270,000 kv-a. and virtually completes the installation necessary to receive the power contracted for from the Gatineau Power Company and the first years' output of power from the Chats Falls development. The construction of the Hydro 220,000-volt transmission lines, together with the receiving station at Leaside is a noteworthy achievement. It is the greatest undertaking of its kind in the

British Empire, and in respect to climatic conditions to be provided for and the undeveloped territory traversed by about half the length of the line, is unprecedented anywhere in the world. The cost of the transmission lines and receiving stations now completed was substantially less than the estimates, thereby lowering the delivered cost of Gatineau power to the Niagara system by nearly $1.00 per horsepower below what had been anticipated when the undertaking was projected. During the year the third circuit on independent towers has been added to convey power to the Niagara system from the new Chats Falls development and power was actually delivered during the last three months of 1931. The capacity of the receiving station at Leaside will be increased as required to handle additional power from this source.

Operating Conditions

During the past year there have been no failures of moment either in station or line equipment, all of which has been maintained in its normal state of efficiency.

The output of many of the smaller hydro-electric generating plants has been curtailed because of the continued lack of rainfall. The deficiency has been particularly noticeable on the Georgian Bay and Eastern Ontario systems and on the Nipissing district where the load demand has remained at approximately the same high level as that established during the two previous years. On these systems the flow of some of the rivers dropped below any flows previously recorded by the Commission. Power shortages would have occurred if the danger had not been foreseen and arrangements, as undernoted, made in time to avert it.

On the Georgian Bay system, the Hanover frequency-changer set, which was placed in operation during the preceding year, enabled power to be transferred from the Niagara system to the Georgian Bay system in amounts sufficient to avert a shortage this year. In the Nipissing district a new transmission line from Sturgeon Falls was completed in January. For about two weeks prior to its completion some restrictions in the use of power were necessary, but thereafter the power from the generating plants of the Abitibi Power & Paper Co., made available by this line was sufficient to meet the shortage in effective generating capacity. On the Eastern Ontario system a new 110,000-volt transformer station was constructed near Kingston, enabling power demands to be met by taking additional 60-cycle power from the Gatineau Power Company at an ealier date than provided in the contract.

With the exceptions noted, there were no difficulties in meeting the demand for power.

COST OF ELECTRICAL SERVICE FURNISHED BY THE COMMISSION

The function of the Commission is not only to use its best endeavours to provide for the people of Ontario an adequate and reliable supply of electrical energy, but also to ensure that the cost of that electrical energy to the consumers shall be the minimum consistent with the financial stability of the enterprise. The success that has been attained in the accomplishment of the latter object may be appreciated by a careful study of the actual

rates to consumers as presented in Statement "E," and of the statistical data setting forth the results that have been attained for the consumers under these rates, as presented in Statement "D," in conjunction with the various financial statements of the Report.

LOAD CONDITIONS

For some years it has been the custom to present at this place in the Annual Report a tabulation showing the coincident peak loads for each of the Commission's systems at the close of the year, as compared with corresponding data for the previous year. The figures that have been presented for the Niagara system in this table have included both the Canadian load and export power. In view of circumstances arising out of the prevailing abnormal economic conditions, the trend with respect to deliveries of power for Canadian use is, this year, more accurately shown by the peak loads exclusive of export power, which loads, in summary, are as follows:*

* Loads and generating capacities must be construed with respect to operating conditions and circumstances. In addition to the comments here given, reference should be made to the general discussion in Section II, and to the graphs of the various systems—especially those for the Niagara system on pages 10 and 11.

The circumstances mentioned make it desirable also, before presenting the more extended table which corresponds to those appearing in previous Annual Reports, to refer to the influence which surplus power has exerted upon some of the totals for the past two years.

Utilization of Surplus Power

As explained in the Commission's Annual Report for 1928, in order to assure continuity of service it is necessary to maintain a margin between the total installed capacity and the anticipated peak load. In most electrical undertakings this reserve capacity, maintained to permit overhaul of units and to meet emergencies, is called upon only for a relatively few hours in the year. Furthermore, even on systems such as those of the Commission which have a high load factor, there are, of course, daily and seasonal peaks, and since the equipment provided must be capable of taking care of the maximum demand whenever it may occur, some additional equipment must be idle during "off-peak" periods, unless a market can be found for the surplus power at such times as it may be available.

In order to effect the maximum utilization of its equipment, the Commission consistently strives to encourage the most uniform use possible

TABLE I.

	October 1930	December 1930	October 1931	December 1931
Niagara system (Canadian load only)	818,526	841,400	756,032	775,180
Other systems, total	262,842	257,878	245,273	253,114
Grand total (Canadian loads only)	1,081,368	1,099,278	1,001,305	1,028,294

of power by its customers. Its ordinary rate schedules for power, for example, enable Ontario consumers using their power for the equivalent of more than about four hours per day to obtain all additional use at lower rates for the additional energy required—in many cities less than one-third of a cent per kilowatt-hour. Special classifications are available to power consumers able and willing to arrange their power demands in a manner that assists in a more economical operation of the Commission's plants, with rates depending upon the degree to which such power consumers are prepared to adjust their demands in order to benefit the system as a whole. Such adjustments agreed to be made by consumers in their demands, range from agreements to accord the Commission the right to interrupt the power during specified hours on specified days at specified times of the year, down to the type of contract under which the Commission is placed under no obligation whatever to supply power except as it may be available and mutually advantageous to the Commission and to the customer.

Power on such special terms, on account of the uncertainties and irregularities involved, is not useable by ordinary industrial consumers, although a limited amount of such power can be and is utilized by large special industries in certain heating, electro-chemical and electro-metallurgical processes. Especially is the market limited for the type of power —known as "at-will" power—under which the vendor assumes no obligation to supply the power except as it may be available after precedence has been accorded to all other demands upon its equipment. With regard to this type of power as well as to all other types of power, the interests of Canadian consumers are given priority of consideration, but the chief market for "at-will" power is in adjacent territory served by power supply systems securing at least a large proportion of their power from steam plants. By utilizing when available this "at-will" power, such systems can, for example, reduce their expenditures for fuel.

The Commission for several years past has been able to reduce greatly the idle time of its generating units at Niagara by disposing of quantities of its surplus power to the Canadian Niagara Power Company for use in the United States under arrangements that permit of its withdrawal *at any time* when required either on account of operating emergencies or for use by Canadian industry. The sale of this power has resulted in a substantial additional revenue to the Niagara system of the Commission. The extra revenue secured involves but little additional operating cost, and therefore reduces the cost of power to Ontario municipalities.

In October and December, 1930, it happened that at the time of the coincident peak loads on the Niagara system no contingencies arose requiring the employment of the margin of surplus capacity, and the Commission, being able to dispose of this surplus power on an "at-will" basis, created peak loads for these months higher than would otherwise have been the case. In 1931, however, due to lessened industrial activity there was a substantial curtailment in the

market for surplus power, and this is reflected in the figures for October and December, 1931, in the table.

It will be appreciated, therefore, that the foregoing considerations must be kept in mind for a correct interpretation of the following tabulation (Table II), which shows the power supplied to the various systems at the close of the year, including, in the case of the Niagara system and of the grand total, export power as well as power for Canadian use.*

The load conditions in the several systems are of special interest this year because of the variations from the usual load trend, as shown in the Operating section of this Report.

Notwithstanding the prevailing industrial depression, slight increases have occurred in the peak loads for some systems, but on the whole there has been a decrease in the total number of kilowatt-hours used.

* See footnote on page 209.

† Eastern Ontario system includes Central Ontario, St. Lawrence, Rideau, Ottawa and Madawaska districts.

Nearly all of this decrease in the kilowatt-hours can be attributed to the lessened demands of certain large chemical and industrial plants which have been particularly affected by the business depression. Omitting some of these large industrial loads in the vicinity of Niagara Falls and in the Thunder Bay system, the decrease in the kilowatt-hours used in the rest of the Province is only one-third of one per cent. The peak load in 1931, with these omissions shows a slight increase over 1930.

Due to the reduced demands of the large chemical, pulp and other industrial plants just referred to, the Niagara and Thunder Bay systems show the largest decreases in load. In this connection it is important to recognize that decreases in actual delivery of power to a system do not imply proportionate decreases in sales of power, or in revenue. The sale of electric power is to a certain degree analogous to a leasing of generating facilities rather than to the sale of a

TABLE II.

DISTRIBUTION OF POWER TO SYSTEMS

20-MINUTE PEAK HORSEPOWER SYSTEM COINCIDENT PEAKS

System	October 1930	December 1930	October 1931	December 1931
Niagara system	1,000,670	1,028,400	805,630	828,200
Dominion Power & Trans. system	58,579	61,528	48,659	56,166
Georgian Bay system	23,355	25,591	26,356	27,531
Eastern Ontario system†	88,678	93,560	85,857	91,253
Thunder Bay system	73,968	61,300	51,600	50,300
Northern Ontario system:				
Sudbury district	12,935	10,724	27,200	21,850
Nipissing district	3,745	3,654	3,689	4,088
Patricia district	1,582	1,521	1,912	1,926
Totals	1,263,512	1,286,278	1,050,903	1,081,314

commodity, and thus just as rentals of leased property continue even though the property may be only partially utilized by the tenant, so the power sold under contract continues to bring in revenue even though not fully utilized. In the Niagara and Thunder Bay systems the power paid for by certain industries exceeded their actual peak loads by an aggregate of about 90,000 horsepower. Consequently, with respect to sales of power and revenues therefrom, the results for the year 1931 are more favourable than might be inferred from consideration of actual deliveries of power as represented by statistics of the peak loads of the systems.

The Georgian Bay system shows an increase in both peak load and kilowatt-hours. The loads in the various municipalities and districts of the Eastern Ontario and Northern Ontario systems showed both increases and decreases, but on the whole remained about the same as during the previous year.

Load conditions may be summed up by stating that there has been a marked decrease in the load of a few large industrial plants, but that except for these plants the consumption of power throughout the Province including that used for domestic and manufacturing purposes has remained at approximately the same level as during the preceding year.

Financial Summaries

It will be observed that the financial statements embodied in this Report are presented in two main divisions, namely, a division—Section IX—which deals chiefly with the operations of the Commission in the generation, transformation and transmission of electrical energy to the co-operating municipalities; and a division — Section X — which deals with the various operations of the municipal electric utilities in the localized distribution of electrical energy to consumers. In Section IX "Rural Operating" reports are also given, which summarize the results of the local distribution of rural electrical service by the Commission to the individual consumers in rural power districts. This work is performed by the Commission on behalf of the respective townships co-operating to provide rural service.

The cumulative results of the operation of the several systems of the Commission as set forth in this Report demonstrate a sound financial condition.

The total investment of the Hydro-Electric Power Commission of Ontario in power undertakings and hydro-electric railways is $267,575,539.68, exclusive of government grants in respect of construction of rural power districts' lines; and the investment of the municipalities in distributing systems and other assets is $105,434,582.32, making in power and hydro-electric railway undertakings a total investment of $373,010,122.00.

Capital Investment

The following statement (Table III) shows the capital invested in the respective systems and municipal undertakings.

Revenue of Commission

The Commission collected from the municipal utilities and other customers, a total sum of $27,908,153.95.

TABLE III.

Niagara system	$182,176,761.94
Undertakings and Companies acquired from the Dominion Power and Transmission Co.	21,489,434.83
Chats Falls development	4,835,702.51
Georgian Bay system	8,203,445.46
Eastern Ontario system (including Nipissing district)	21,570,767.11
Thunder Bay system	18,406,363.39
Northern Ontario system (Sudbury, Abitibi, and Patricia districts)	5,259,255.71
Hydro-Electric railways	1,897,838.32
Office and service buildings, construction plant, inventories, etc.	3,735,970.41
	$267,575,539.68
Municipalities distributing systems and other assets (exclusive of $20,103,275.76 of municipal sinking fund equity in H.E.P.C. system)—all systems	105,434,582.32
	$373,010,122.00

This sum was appropriated to meet all the necessary fixed charges and to provide for the expenses of operation and administration. After meeting all charges there was left a net surplus of $658,751.64.

The following statement (Table IV) summarizes the Commission's collections from municipal electric utilities and other power customers for the year and shows how the collections have been appropriated:

TABLE IV.

Revenue from municipal electric utilities and other power customers		$27,908,153.95
Appropriated as follows:		
Operation, maintenance, administration, interest and other current expenses	$22,093,507.05	
Reserves for sinking fund, renewals, contingencies and obsolescence provided in the year	5,155,895.26	
		27,249,402.31
Net surplus credited to municipalities under cost contracts		$658,751.64

NOTE.—The above figures do not include the revenue from the operation of the undertakings and companies which were acquired by the Commission from the Dominion Power and Transmission Company, Limited, as from January 1st, 1930. From this date the Commission has continued the operation thereof under the various company franchises, and a separate revenue and expense statement is shown for these.

TABLE V.

RURAL POWER DISTRICTS—OPERATIONS FOR THE YEAR 1931

	Niagara system	Georgian Bay system	Eastern Ontario system	Totals
	$ c.	$ c.	$ c.	$ c.
Cost of power as provided to be paid under Power Commission Act	713,359.34	78,587.02	147,973.41	939,919.77
Cost of operation, maintenance and administration	460,488.04	37,936.44	102,331.89	600,756.37
Interest	232,017.53	23,837.08	57,205.62	313,060.23
Renewals	208,799.24	20,126.72	48,946.74	277,872.70
Obsolescence and contingencies	104,399.62	20,126.72	24,473.37	148,999.71
Sinking Fund	55,496.81	5,584.70	13,101.69	74,183.20
Total expenses	1,774,560.58	186,198.68	394,032.72	2,354,791.98
Revenue from customers	1,888,536.58	170,968.00	397,484.65	2,456,989.23
Net surplus, all districts	113,976.00	....	3,451.93	117,427.93
Net deficit, all districts	....	15,230.68	....	15,230.68
Net surplus, all systems	....	....	....	102,197.25

Rural Electrical Service

During the past few years very substantial progress has been made in Ontario in the field of rural electrification. Practically all rural electrical service is now given through rural power districts which are operated directly by the Commission. There is now rather more than $15,507,000 invested in the rural power district systems established by the Commission. Towards this rural work the Ontario Government, pursuant to its policy of promoting the basic industry of agriculture, has, in the form of grants-in-aid, contributed 50 per cent. of the costs of transmission lines and equipment, or some $7,677,000. A total of 8,197 miles of transmission lines have been constructed to date, of which 1,470 miles were constructed during the past year. There are now more than 55,000 customers supplied in the rural power districts.

Municipal Electric Utilities

The following (Table VI) is a summation of the year's operation of the local electric utilities conducted by municipalities receiving power under cost contracts with the Commission:

TABLE VI.

Total revenue collected by the municipal electric utilities		$31,657,564.88
Cost of power	$18,409,304.24	
Operation, maintenance and administration	5,698,056.49	
Debenture charges and interest	4,569,568.79	
Depreciation and other reserves	1,793,111.69	
Total		30,470,041.21
Surplus		$1,187,523.67

RESERVES OF COMMISSION AND MUNICIPAL ELECTRIC UTILITIES

The total reserves of the Commission and the municipal electric utilities for sinking fund, renewals, contingencies and insurance purposes amount to $115,639,726.38 made up as follows (Table VII).

The consolidated balance sheet of the municipal electric utilities, on page 270, shows a total cash balance of $2,738,319.67, and bonds and other investments of $1,999,846.42. The total surplus in the municipal books now amounts to $37,794,134.98 in addition to depreciation and sundry other reserves aggregating $15,441,179.51.

The following is a brief summary of the principal operations relating to the several systems of the Commission:

NIAGARA SYSTEM

The Niagara system embraces all territory lying between Niagara Falls, Hamilton and Toronto on the east and Windsor, Sarnia and Goderich on the west served with electrical energy generated at plants on the Niagara River, supplemented with purchased power transmitted from plants on the Gatineau River and the Ottawa River. A few municipalities and districts of the Niagara system are served also with power developed at Decew Falls.

Power as supplied to the Commission by the Gatineau Power Company is received by the Commission at the interprovincial boundary on the Ottawa River and is transmitted over two 220,000-volt steel-tower transmission lines to Leaside. Power obtained from Chats Falls development on the Ottawa River, which plant is being constructed jointly by the Commission and the Ottawa Valley Power Company, formerly the Chats Falls Power Company, is transmitted from Chats Falls to Leaside over a third 220,000-volt steel-tower line, which was completed and put into operation during the year.

Arrangements have already been made for additional power for this system, which should be adequate for a number of years ahead. In addition to power contracted for with the Gatineau Power Company and additional power to be obtained from the development at Chats Falls, which will provide the Commission with 216,000 horsepower, the Commission has

TABLE VII.

Niagara system	$48,503,212.29
Georgian Bay system	2,197,526.09
Eastern Ontario system	4,865,154.23
Thunder Bay system	2,597,316.84
Northern Ontario system—Sudbury and Patricia districts	86,941.78
Service building and equipment	616,737.10
Hydro-Electric railways (Guelph)	98,728.80
Insurance, workmen's compensation and staff pensions	3,438,794.76
Total reserves of the Commission	$62,404,411.89
Total reserves of municipal electric utilities	53,235,314.49
Total Commission and municipal reserves	$115,639,726.38

arranged to purchase additional power, amounting to 250,000 horsepower, to be developed on the St. Lawrence River by the Beauharnois Light, Heat & Power Company, and 125,000 horsepower to be delivered to the Commission as required from a plant on the Lièvre River under a contract with the James MacLaren Company Limited, subsequently assigned to a subsidiary power company known as MacLaren-Quebec Power Company.

Since the purchase of the undertakings and companies of the Dominion Power & Transmission Company Limited, the operation of these properties has been continued by the same staff but under revised supervision. An agreement was entered into with the Hamilton Hydro-Electric System by which the Commission sold to the city of Hamilton the distribution system, substations and other properties in the city.

Negotiations are proceeding in connection with the taking over by the cities of Brantford and St. Catharines of subsidiary companies in these cities on the same basis as Hamilton.

The total capital invested by the Commission on behalf of the co-operating municipalities of the Niagara system is $182,176,761.94, and the accumulated reserves for renewals, obsolescence, contingencies and sinking fund, aggregate $48,503,212.29. This is exclusive of the undertakings and companies purchased from the Dominion Power and Transmission Company, Limited, for which separate statements of assets and liabilities, and operations are presented.

From the rural power districts of this system, which are directly operated by the Commission, the revenue received for the year from customers was $1,888,536.58, and the total cost of supplying the service was $1,774,560.58, leaving a balance of $113,976.00, which is placed to the credit of districts in this system.

With respect to the electric utilities of the various urban municipalities of the Niagara system, the actual cost of power supplied by the Commission during the year was $647,413.52 less than the total amount collected at the interim rates, and this sum has been credited to the Municipal Utilities. The total revenue of the municipal electric utilities served by this system was $26,275,001.25, an increase of $1,443,832.54.

The total net surplus for the year from the operation of the various municipal electric utilities was $830,967.09, after providing $1,524,420.75 for depreciation and other reserves and $1,885,361.96 for the retirement of instalment and sinking fund debentures. Forty-one municipal utilities had deficits upon the year's operations, aggregating $42,003.20, whereas the total combined surplus of the other municipal electric utilities served by this system was $872,970.29.

Georgian Bay System

The Georgian Bay system serves the area adjacent to Georgian Bay including the counties of Bruce, Grey, Dufferin and Simcoe and the northern portions of the counties of Huron, Wellington and Ontario, as well as a large portion of the district of Muskoka.

The main supply of electrical energy

for the district is obtained from eight hydro-electric developments, three situated on the south branch of the Muskoka River, two on the Muskoka River at Bala, two on the Severn River, and one on the Beaver River, supplemented by power from the Niagara system obtained through two frequency-changer stations at Mount Forest and Hanover. Power is also obtained for secondary purposes from small developments at Hanover, Walkerton and Southampton, the combined capacity of which approximates 1,300 horsepower.

During the year the properties acquired in Bruce County from The Public Utilities Consolidated Corporation, a subsidiary of The W. B. Foshay Company of Minneapolis, namely The Walkerton Electric Light & Power Company, and The Saugeen Electric Light & Power Company, were consolidated with the Georgian Bay system and the distribution systems in four of the principal towns were purchased by the municipalities and placed under local management after by-laws had been passed by the ratepayers, and agreements entered into with the Commission.

Contracts for a supply of power were executed with the municipalities of Port Elgin, Southampton, Walkerton, Wiarton and Rosseau.

Although there was in the Georgian Bay system a small decrease in the demand for power in the urban centres, the difference was more than made up by an increase in the demand in the rural districts caused by extensions to existing districts and establishment of new districts. This increase, together with the demands of the new municipalities served in Bruce County, has resulted in a total peak load, approximately 1,200 horsepower in excess of that for the previous year.

The total capital invested by the Commission on behalf of the co-operating municipalities of the Georgian Bay system is $8,203,445.46, and the accumulated reserves for renewals, obsolescence, contingencies, and sinking fund aggregate $2,197,526.09.

The revenue received for the year from customers in rural power districts of this system which are directly operated by the Commission was $170,968.00, and the total cost of supplying service was $186,198.68, leaving a balance of $15,230.68, which has been charged to districts in this system.

With respect to the electric utilities of the various urban municipalities of the Georgian Bay system, the actual cost of power supplied by the Commission for the year was $47,371.33 in excess of the revenue from the interim monthly billing. This sum has been charged to the municipalities operating under cost contracts. The total revenue of the municipal electric utilities served by this system was $1,115,202.82, an increase of $64,101.28 over the previous year.

After charging $62,450.70 for depreciation reserve and $58,994.83 for the retirement of instalment and sinking fund debentures, the net shortage from the operation of the various municipal electrical utilities was $40,777.97.

Eastern Ontario System

This system serves all of Ontario east of the areas comprising the Georgian Bay and Niagara systems

It includes the following districts: Central Ontario, St. Lawrence, Rideau, Ottawa and Madawaska.

The sources of power for the Eastern Ontario system comprise developments owned by the Commission on the Trent canal system and on the Mississippi and Madawaska Rivers, and purchased supplies from the Cedar Rapids Power Company, the Gatineau Power Company, the Rideau Power Company, the Corporation of Campbellford and Beach Estate at Iroquois.

During the year, the voltage of the transmission line from Smiths Falls to Kingston, over which the power purchased from the Gatineau Power Company is supplied, was increased from 44,000 volts to 110,000 volts and a new transformer station erected at Kingston. This required alterations to the station at Forfar to transform from 110,000 volts to 8,000 volts for the Smiths Falls rural power district.

The Commission sold the local distribution systems in Tweed, Deseronto and Bowmanville to the municipalities, on the basis of the value of these systems as recorded in the books of the Commission. Each municipality was credited with the accumulated renewals reserves set up in respect of the properties purchased by it. These municipalities submitted by-laws to the ratepayers and entered into agreements for the supply of power from the Commission.

The villages of Bath and Westport also signed agreements for the purchase of power from the Commission and lines are being constructed to supply these municipalities.

The load requirements of the system did not increase as much as was anticipated over the previous year, but owing to a deficiency of precipitation and resulting low water on the Trent Canal system and other rivers on which the Commission's generating plants are situated, it was necessary to call on the Gatineau Power Company for the annual increment of 6,000 horsepower in September, which normally is provided under the term of the contract on October 1st of each year, and arrangements were made to obtain additional power temporarily from the Cedar Rapids Power Company for the St. Lawrence district. All demands for power for the requirements of the system were thus met and the Commission's future needs for the system are amply provided by the existing contract for purchased power.

The total capital invested by the Commission on behalf of the co-operating municipalities of the Eastern Ontario system is $21,570,767.11, and the accumulated reserves for renewals, obsolescence, contingencies and sinking fund aggregate $4,865,-154.23.

In the rural power districts of this system, which are directly operated by the Commission, the revenue received for the year from customers was $397,484.65, and the total cost of supplying the service was $394,032.72, leaving a balance of $3,451.93, which is placed to the credit of districts in this system.

With respect to the electric utilities of the various urban municipalities of the Eastern Ontario system operating under cost contracts the actual cost of power supplied by the Commission during the year was $15,243.53 less

than the total amount collected at the interim rates and this has been credited to the municipal utilities. The total revenue of the municipal electric utilities served by this system was $2,883,777.62, a decrease of $3,357.83.

The total net surplus for the year from the operation of the various municipal electric utilities was $282,598.13, after providing $167,988.00 for depreciation and other reserves and $115,336.41 for the retirement of instalment and sinking fund debentures. Five municipal utilities had small deficits upon the year's operations, aggregating $1,390.55, whereas the total combined surplus of the other electric utilities served by this system was $283,988.68.

Thunder Bay System

The Thunder Bay system serves that part of the Thunder Bay district lying between Lake Nipigon and the international boundary, including the cities of Fort William and Port Arthur, and the village of Nipigon. The greater portion of the developed power is utilized by grain elevators and pulp and paper mills, and due to the world-wide depression which has largely affected the power demands of these two major industries, the load on this system has fallen off considerably. However, taking account of the good financial history of this system there is every reason to believe that it will continue to operate with an excellent showing as in previous years.

The Commission has, in the Thunder Bay system, a total investment of $18,406,363.39, and accumulated reserves for renewals, contingencies, and sinking fund aggregate $2,597,316.84.

The actual cost of power supplied to this system by the Commission for the year was $44,814.76 in excess of revenue from the interim monthly billing, which sum has been charged to the municipalities operating under cost contracts. The total revenue of the municipal electric utilities in this system was $1,383,583.19 The three municipalities served by this system operated with a net surplus of $114,736.42 after providing depreciation to the extent of $38,252.24 and $21,655.10 for the retirement of debentures.

Northern Ontario System

This system covers all of the Province north of the French River and Lake Nipissing except the territory served by the Thunder Bay system. Certain areas of the Northern Ontario system are served by separate developments, and engineering assistance and advice covering management and operation are given by the Commission to all municipalities and unorganized sections of the area when requested. The principal active sections at the present time are the Nipissing district, the Sudbury district, the Abitibi district, and the Patricia district.

Nipissing District

This district comprises the area adjacent to the eastern shores of Lake Nipissing; the municipalities served include the City of North Bay, the villages of Callander and Powassan, and the townships of Ferris, Himsworth and Nipissing. Power is obtained from three hydro-electric developments on the South River,

namely, Nipissing, Bingham Chute, and Elliott Chute. Owing to low water conditions in this district, due to lack of precipitation, arrangements were made with the Abitibi Power and Paper Company for an emergency supply of power from its development at Crystal Falls (formerly known as Smoky Falls) on the Sturgeon River and a transmission line was constructed and placed in operation between North Bay and Sturgeon Falls. For purpose of financial administration the Nipissing district of the Northern Ontario system is associated with the districts of the Eastern Ontario system.

Sudbury District

The active area in this district lies in and adjacent to the City of Sudbury, including the mining area known as Sudbury Basin, the source of power supply being the three developments recently purchased from The Wahnapitae Power Company. The load at Sudbury and the adjacent district, although not as large as when mining operations are normal, has continued fairly steady throughout the year, with the result that the financial operations for the district have been satisfactory.

Abitibi District

The active area in this district comprises the territory within transmission distance on both sides of a transmission line constructed during the year from Hunta just west of Cochrane to Copper Cliff. Power is obtained under a contract entered into by the Commission with The Ontario Power Service Corporation, Limited. This line was placed in service on October 5th and the Commission is prepared to deliver the block of power now under contract with The International Nickel Company.

Patricia District

The active section in this district is the Red Lake mining area. Power is developed at Ear Falls at the foot of Lac Seul, and supplied to one of the leading gold mines in the district. The Commission is prepared to supply all power demands in the district within transmission distance of this development.

The Annual Report

The Table of Contents, pages xxv and xxvi, conveys a good understanding of the scope of the matters dealt with in the Report, to which there is also a comprehensive Index. To those not conversant with the Commission's Reports the following notes will be useful.

In Section II, pages 6 to 59, dealing with the Operation of the Systems, are a number of interesting diagrams showing, graphically, the monthly loads on the various systems. Tables are also presented showing the amounts of power taken by the various municipalities in October during the past three years.

The rural distribution work of the Commission has proved of widespread interest and special reference to this is made in Section III, on pages 67 to 85. The power distributed to rural districts is, and possibly must always be, but a relatively small proportion of the power distributed by the Commission. The supplying of electrical service in rural areas, and especially on the farm, has, however, been of great economic benefit to Ontario.

The Provincial Government grants-in-aid to this work have been of value to agricultural activities, and have assisted the Commission to extend rural transmission lines to many areas.

In Sections IV, V and VI will be found information respecting progress of work on new power developments and on transmission system extensions, together with photographic illustrations.

About one-half of the Report is devoted to statistical, financial data which are presented in two Sections, IX and X.

Section IX presents in summary form the financial statements relating to the operations of the Commission chiefly in the generation, transformation and transmission of electrical energy to the co-operating municipalities. It is introduced by an important explanatory statement which appears on pages 143 to 147, to which special reference should be made.

Section X presents in summary form the financial statements relating to the operations of the municipalities in the localized distribution of electrical energy to consumers. It also contains details of the costs of electrical energy to consumers in the various municipalities and tabular statements of the rates in force which have produced these costs. An explanation of the various tables and statements is given at the commencement of this Section on pages 263 to 265; and a special introduction to Statement "D", which relates to the cost of electrical service in Ontario, together with a diagram, appears on pages 382 to 385.

In its Annual Reports the Commission aims to present a comprehensive statement respecting the activities of the whole undertaking under its administration. Explanatory statements descriptive of the operations of the Commission in various branches of its work are suitably placed throughout the Report in order that the citizens of the Province may be kept fully informed upon the working-out of the Commission's policies.

The Commission receives many letters asking for general information respecting its activities, as well as requests for specific information concerning certain phases of its operations. In most cases these enquiries can satisfactorily be answered by simply directing attention to information presented in the Annual Report of the Commission. Real benefit would result to the "Hydro" undertaking if those who are commenting upon aspects of the Commission's work would first make sure by consulting the Commission's publications that the data upon which their comments are to be based are adequate and pertinent to the subject in hand. By such a course much misrepresentation, as well as inconvenience, would be avoided.

Other Publications by the Commission

From time to time, as considered desirable in the interests of the co-operating municipalities, the Commission has published, in addition to its Annual Report, pamphlets and special statements dealing with variour matters of interest. Thus, at the close of the past year there was in course of preparation a pamphlet which has since been issued, entitled: "Rural Electrical Service in Ontario:

A Statement Outlining Its Relationship to Electrical Service in Cities and Towns and Correcting Some Misunderstandings." This pamphlet deals with important facts concerning the rural work of the Commission, explains the relationship of electrical service in the rural power districts of Ontario to that given in cities and towns and clears up certain misunderstandings respecting rural electrical service and the cost of such service to consumers.

In connection with public statements made by the Commission, it is a pleasure to record that, as matters of public interest, the Press has given generously of services and space in order to convey to the citizens of Ontario information respecting their "Hydro" undertaking. For this the Commission desires to express its gratitude.

The Present Situation

In closing this introductory statement it will be profitable to refer briefly to the present economic situation and its influence upon the "Hydro" undertaking; and while one is reluctant to keep referring to the existing depression, yet its pronounced character and the extended period over which it has prevailed have, to a greater or lesser degree, affected practically all electrical supply undertakings and the "Hydro" undertaking has not escaped.

In the foregoing review the load conditions have been referred to rather more fully than usual, and under the circumstances it is a satisfaction to be able to state that, compared with many similar undertakings, the "Hydro" enterprise has maintained its load at a relatively favourable level; its revenues and the revenues of the associated municipalities have to a noteworthy degree also been maintained, and the reserves of the undertaking have continued to increase substantially. However, while the load supplied to the municipalities has been well maintained, certain large industries directly supplied by the Commission are not using all of the power contracted for; and, furthermore, there has been a suspension of growth in the load for which the Commission—conservatively basing its estimate upon past experience—had made provision. On the other hand, the Commission at the commencement of the period of depression, had practically no margin between its available supplies and the actual demands. For a year or more following, the Commission, with its provisions for power supplies, was merely building up a reasonable reserve in relation to the power actually in use. Again, a substantial part of the existing margin of capacity represents power sold under contract, for which the Commission is being compensated, and which it is under obligation to hold as a reserve, immediately available when called for.

It is recognized as an essential in electricity supply undertakings to maintain over and above the estimated maximum load, a surplus of capacity sufficient to ensure uninterrupted service in the event of damage to equipment, or temporary reduction in effective capacity due to ice difficulties, unusual variations in rainfall or other contingencies; to enable units to be taken out of service

for regular maintenance work and repairs; to provide a margin for unpredictable variations in peak loads due to exceptional over-lapping of the demands of different consumers; and to provide a margin for additional demands resulting from increased industrial activities or other causes. This reserve capacity, as ordinarily maintained by large systems, ranges from 10 per cent. to as high as 30 per cent. or more, of the normal operating capacity.

A Broader Outlook Necessary

The whole question of provision for future demands, however, has to be dealt with by the Commission in a broad and comprehensive manner. As a basis for estimating future demands, special reliance must be placed upon past records of growth in load extending over a reasonable period which includes years of prosperity and years of decreased activity. In this connection it must be recognized that in modern communities there is a steady growth in demand for electrical service, due to growth in population and to an increase in individual consumption, which growth in demand goes on to a greater or lesser degree irrespective of the cyclical phenomena of prosperity and depression. This growth is, however, partially or entirely obscured during periods of depression by reason of a recession in the demand for power for industrial purposes.

Bearing the foregoing considerations in mind, it must also be appreciated that only large hydro-electric developments are capable of providing adequate additional supplies of power for an electrical undertaking of the magnitude of the Niagara system of the Commission. Such large developments take years to plan and construct. It is, therefore, necessary to plan several years ahead for the anticipated growth in demand. It is of the utmost importance that the general economic and industrial growth of Ontario should not be hampered by shortage of power supplies. If, after provisions have been made for increased power supply, there should, in the interim, come, in the cycle of economic events, a period of depression with its lessened demands for power, it simply means that during a continuance of the depression there will be an increasing margin between the aggregate supplies of power being made available, and the actual demands. This is a quite natural phenomenon and one which need occasion no undue concern, because past experience has always shown that the power supplies made available are taken up and utilized at a rapid rate quite early in the turn of the cycle towards more normal social and economic conditions.

The Commission, with a recognition of the bountiful natural resources of the Province and with an assured faith in the ability of the citizens of Ontario to weather the present period of distress, goes forward into the coming year confident that the future will justify its course in providing for the citizens of Ontario ample supplies of power, and hopeful for an early return to more favourable economic conditions.

Respectfully submitted,

J. R. COOKE,

Chairman

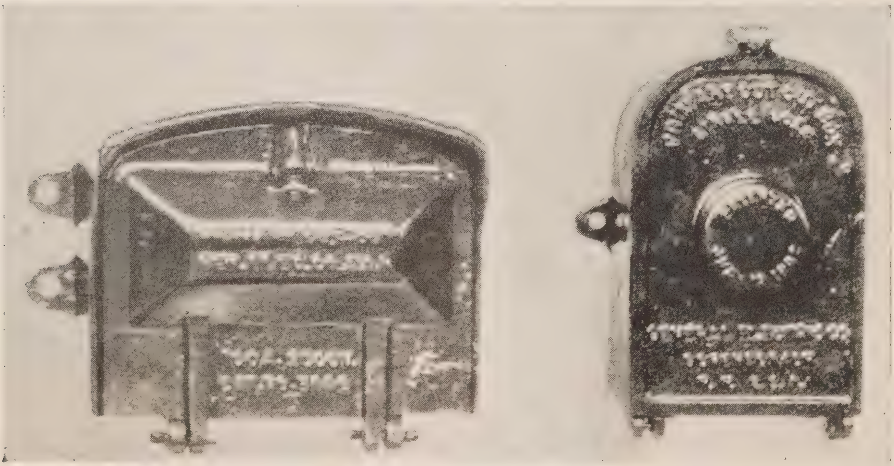
Development of Fuse Cutouts

By R. E. Jones, Assistant Engineer, Distribution Section, Electrical Engineering Dept., H.E.P.C. of Ontario

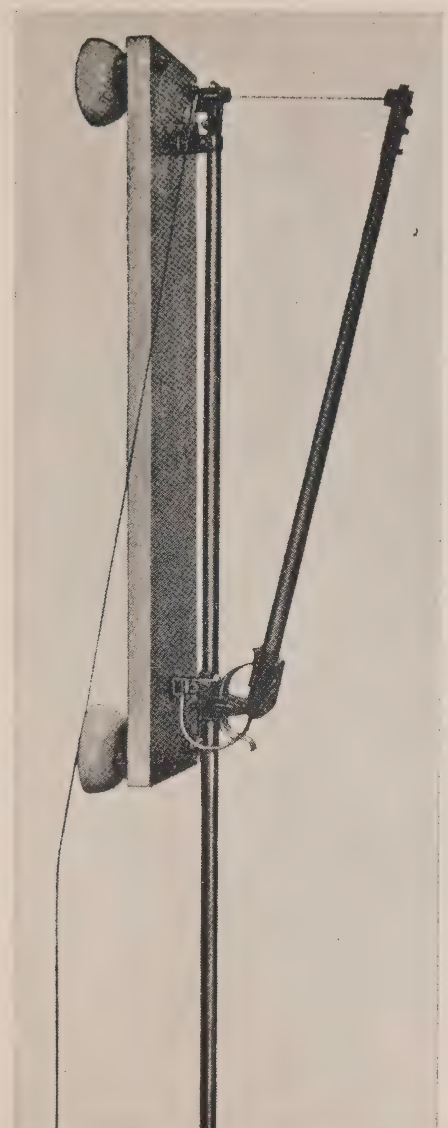
(Presented to Association of Municipal Electrical Utilities at Bigwin Inn, Muskoka, June 23, 1932)

WHEN distribution transformers were first used the voltage was comparatively low and the capacity of the system small. For many years a few inches of fuse wire, stretched on a piece of dry process porcelain gave good service. Occasionally the cutout arced across and finally burnt clear. Some efforts were made to overcome this trouble by adapting the small cartridge fuse used for low voltage service; this was housed in various forms of casing. In another cutout the fuse element was placed between porcelain blocks pressed together. An improvement over the plain lead and tin wire was the soldering of copper terminals on the ends of the fuse wire. Aluminum was also used for fuses but oxidization and crystallization both caused trouble in the small sizes.

The next step in fuses was in the use of the expulsion type of cutout. The fuse link is enclosed in a tube which is closed at one end. The explosive action of the blowing fuse ejects the hot gases from the tube and tends to prevent arcing. The ejecting force of the explosion is a function of the amount of metal vaporized, the length of time taken to melt the metal, and the size of the bore. The bore must necessarily be a compromise between a size small enough to assure ejection of the gases and one large enough to allow the gases to escape without bursting the tube. As conditions vary, it is impossible to design a tube which will work under all such conditions. Under



Early cutouts with porcelain blocks in iron housings. 1907 and 1909.



This "drop out" fuse switch was in use previous to 1902. To operate, it was necessary to pull the string shown.

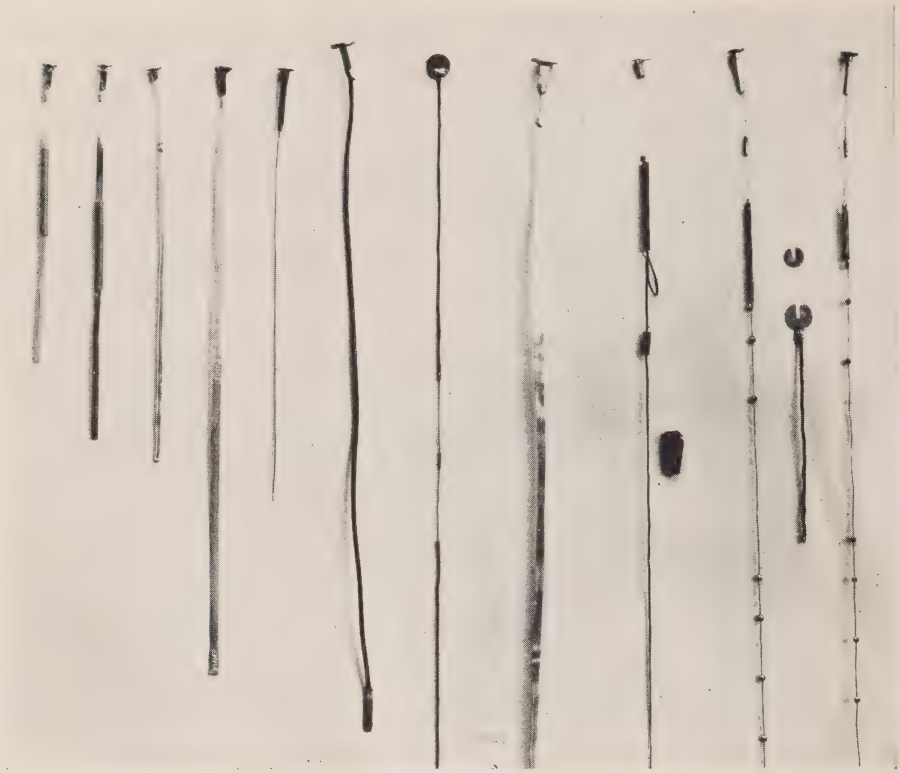
conditions usually existing on distribution lines the current is not sufficient to shatter the tube. On the other hand the current causing the fuse to blow, frequently is just enough to melt the wire without causing an explosion to eject the gas. The result is arcing between the ends of the fuse wire with subsequent charring of the tube and probably its destruction. Fibre tube has the characteristic of resisting carbonizing more than bakelite but will not withstand the weather. A number of devices have been contrived to overcome this trouble with "slow blow". Among these are the use of a spring in the fuse element; the placing of a fibre tube immediately around the fuse to supply a small bore for "slow blows"; and the use of various metal combinations such as a short piece of tin wire to give a low melting point with aluminum leads to suppress the arc.

Several of the earlier types of cutout were housed in iron boxes. While appearing dangerous to us they did not cause much trouble then. They were superseded by the porcelain plug type which was in common use for about 20 years. This consisted of a dry porcelain weather proof box with a porcelain plug inserted from below and held in place by spring contacts. A piece of fuse wire was stretched over the top end of the plug from contacts near the handle. With the use of grounded circuits, in wet weather there was frequently leakage through the porcelain to the crossarm with resulting burning of arms. Also this type of cutout was somewhat limited in its short circuit capacity.

Next came the wooden box cutout with the expulsion cartridge mounted on the door in such a way that the circuit was opened with the door.

The dry process porcelain box with a composition door holding the fuse cartridge followed.

Due to trouble from leakage in wet weather the dry process porcelain was



Various types of modern fuse link.

replaced with wet process. Later the fibre composition door was replaced by a bakelite door. Since then satisfactory wet process porcelain doors have been placed on the market.

Another type of enclosed cutout that came out a few years ago consisted of a cylindrical body of wet process porcelain with a fuse tube mounted on a wet process porcelain handle. The fuse was inserted from the top of the tube. Following this a similar cutout was designed in which the cartridge was inserted from the bottom.

For heavy short circuit capacity an enclosed cutout was made with an iron case containing oil. The fuse thus opened the circuit under oil preventing a serious arc.

For many years the open type of fuse switch was used on higher voltages. More recently a lot of development work has been done on this type of cutout.

The early fuse switch consisted of a fibre tube with contacts at each end and hinged at the bottom to a fitting on an insulator. The top end closed into a fitting on another insulator. Contacts at both ends consisted of flat springs, stiff enough to hold the cartridge in place. The stiff contacts were later replaced with floating contacts with a latch, to permit easier operation; a white porcelain tube was

used to cover the bakelite tube both for protection from the weather and to improve the visibility at night.

One type used a special fuse under tension to hold in a latch. Upon opening of the fuse link the tube was released at the top and swung open on its hinge.

Another switch used a fuse cartridge containing a small amount of gun powder. When the fuse blew the powder was ignited and blew away an auxiliary arm which in turn drew out the bakelite cartridge.

A form of fuse used more generally on the higher voltages was the tetrachloride fuse. The fuse element was held in tension by a spring and the whole was enclosed in a sealed glass tube which was filled with carbon tetrachloride. Upon blowing of the fuse, one end of the fuse was pulled through the liquid quenching the arc at once.

The following points must be considered in selecting a cutout:—

A fuse should be so designed as to properly protect the apparatus to which it is connected. On the other hand in performing this function it should not cause unnecessary interruptions to service.

The rating of the fuse should be definitely understood. At present there are two views on the question of rating. The manufacturers prefer to consider a fuse as able to carry 65 per cent. of its rating indefinitely. The power companies desire a fuse that will carry 100 per cent. of rating.

A cutout must withstand the weather and require no attention over a long period of years.

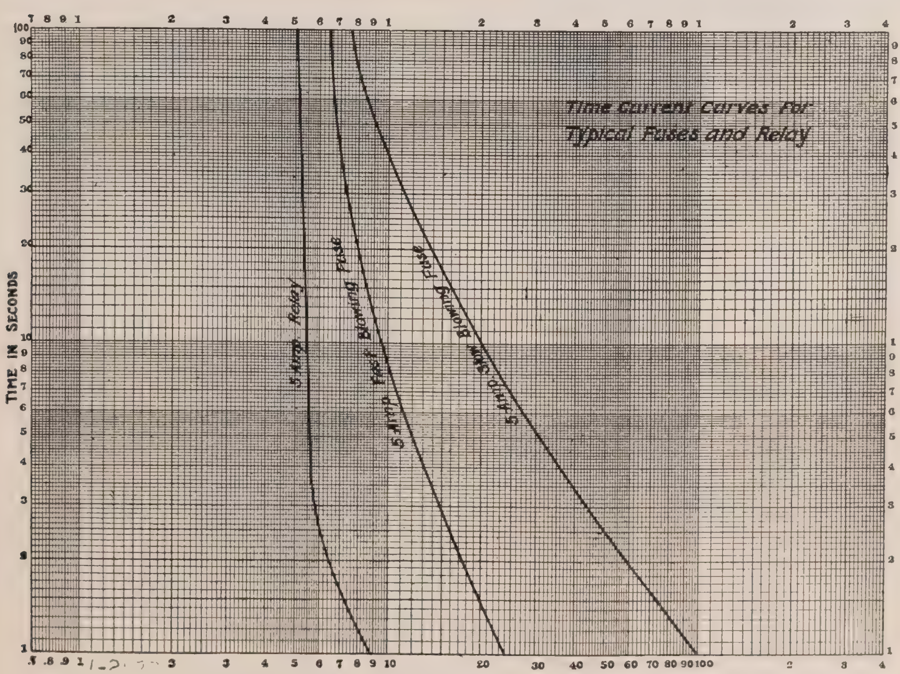


Chart showing time current characteristics of typical fuses and relay.

Set for 12 kv. tests with one fuse blowing at 240 amperes.

Contacts and other metal parts must be so designed as not to cause radio interference.

Tubes may be of fibre if well protected from the weather. Otherwise a double tube with fibre inside and bakelite outside is preferable. The blowing of fuses erodes the fibre like sand-blasting whereas a bakelite tube is more readily carbonized.

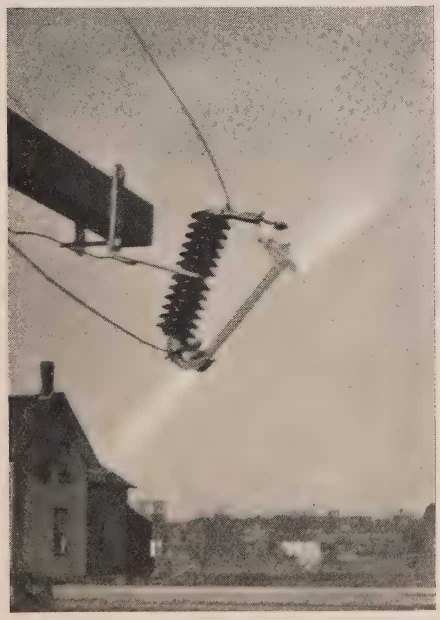
The fuse should not operate at a temperature high enough to damage the tube. Tin has the property of melting at a lower temperature than aluminum whereas the latter tends to prevent arcing. It is difficult to design a fuse link fast enough to co-ordinate with relays. On the other hand a slow fuse will blow less frequently with quick overloads or lightning. Some utilities have standardized on 10 ampere as the minimum size of transformer fuse in place of a smaller fuse in order to give better service. They find that the cost of replacing transformers burnt out from over-load is more than offset by the reduction in blown fuses, as well as giving better service to the consumer.

The fuse should fit as many makes of cutout as possible. With this in view nearly all manufacturers have adopted the button-head as standard. It should also be mechanically strong, especially in the smaller sizes and should not be of such a design that the fuse could be broken and the defect not be visible.

Insulation should be high enough to be safe and to give good service.

Drop out switch with standard bakelite tube arcing at 12 kv., 240 amperes.

Short circuit test on a drop out switch. 1,600 amperes, 4 kv.



Same switch under similar conditions, using special Canadian made bakelite tubes.

A.I.E.E. Rules specify 2¼ times rated voltage plus 2000. National Electric Manufacturers' Association rules specify clearances and particularly that the flash-over to ground shall be less than between terminals.

Load Building Possibilities With Electric Heating Devices

By J. S. Keenan, Assistant to the Manager, General Merchandising Dept., Canadian General Electric Company, Limited, Toronto

(Presented to Association of Municipal Electrical Utilities at Bigwin Inn, Muskoka, June 25, 1932)

THE installed hydro-electric generating capacity in Canada was increased during the year 1931 by 545,000 horsepower approximately 9 per cent., bringing the total to 6,670,000 horsepower. Additional installations scheduled for completion during 1932 will increase the capacity by a further 13 per cent. or 850,000 horsepower, bringing the total to 7,520,000 horsepower. The 16,600,000,000 kilowatt hours generated by the Central Station industry in Canada during the year 1931 represent a decrease of approximately 8 per cent. from the output of the year 1930. While the consumption of energy in the homes of the nation has continued to increase at a gratifying rate year after year, curtailed manufacturing schedules have resulted in a material decrease in consumption by industries, more than offsetting the increases in household requirements.

The electric energy consumed by industries may be classified under three headings, namely, motive power, lighting, and heat used in manufacturing processes. Since the energy required for motive power is almost directly proportional to manufacturing output, increases in this field must await the return of enlarged manufacturing schedules, except insofar as concerns using other sources of energy can be induced to use Central Station power.

Increased illumination, both interior and exterior, usually results in an economic advantage to the user, as well as the supplier of current. Industrial and commercial establishments can be sold on the benefits to them of increased illumination and efforts in this direction should be continued without relaxation.

The other important industrial and commercial field, namely, process heat, is particularly important at this time, because the use of electrical energy can be greatly increased, even under present economic conditions. Electrical energy so used displaces competitive fuels, mostly imported, such as fuel oil and coal. It has a distinct appeal because it is directly used in production and because in many cases it results in a decided reduction in manufacturing costs and improves quality, as well as reducing manufacturing time and thereby permits quicker shipments to be made. Surveys which have been made indicate that the present economically justified use of process electric heat is equal to the present industrial motor load. Aggressive sales efforts, such as those which in past years have caused Central Station power to displace other forms in industry will in future cause Central Station heat

to displace other process heating methods.

Experience indicates that during the year 1932, particularly, electrical manufacturers and utilities are well advised when promoting the sale of current consuming devices to industrial and commercial establishments, to concentrate on devices of relatively low first cost. It is the purpose of this paper to deal with low-priced, industrial heating devices and with domestic water heaters, both of which consume annually quantities of electricity relatively very large in comparison with the first cost of the device. The two will be treated separately; industrial heating first, and water heating second.

I have endeavoured in preparing this paper to as far as possible deal with practical and definite procedures to be followed in getting these current consuming devices on the lines rather than merely a theoretical discussion of their value to the utility.

Industrial Heating

The electrical manufacturers recognize that their future growth is largely dependent upon the growth of the nation's central stations. A number of manufacturers, always eager to find new outlets for their products, have clearly seen for several years past the huge potential load of small heating units and devices for industrial plants. While they have made important progress in popularizing such equipment, the Central Station has a very vital part in the picture, and with their added efforts, much more can be accomplished.

As near as we can estimate, the total potential, industrial electric heating, connected load in Canada approximates 5,000,000 kw. Of this 5,000,000 kw. not more than 500,000 kw., or less than 10 per cent., is already connected. This is exclusive of large electric steam boilers of which there is more than one million kilowatts connected. It is estimated that of all the sales of industrial electric heating equipment so far made, over 50 per cent. has been in the line of small heating units, such as soldering irons, strip heaters, glue pots, soft metal melting units, etc. This percentage will remain approximately the same in future sales. These figures indicate that greater commercial effort is justified and industrial electric heating should at this time be given commercial push commensurate with its possibilities.

While all branches of electric industrial heating hold tremendous load-building possibilities, it is particularly advisable at this time to concentrate on units of low cost because on those, the sales resistance is low, the market is broad, practically unlimited, and the immediate load-building possibilities are tremendous. This type of load is most desirable for several reasons. A large part of it is 24-hour a day load; much of it is off-peak; it is a load that returns large revenue per kw. connected; it is unity power factor load and, as such, requires little, if any, added plant investment. It is estimated that in the last five years quantities of these small industrial heating devices, amounting to 100,000 kw. in total rating, have been sold and put into service in Canada. The market is a vast one. Practically every type of industry is a prospect

or user of one or more types. A manufacturer does not need a gilt-edged credit rating to be a live prospect. The smallest concern with very limited capital can buy these low-priced units and pay cash, thus greatly extending the market. This particular equipment readily lends itself to merchandising. It can be purchased by the electrician or the maintenance engineer without authorization by the Board of Directors or red tape. It is the type of equipment that stays on the line even during periods of depression, when other equipments which are integral parts of a mass production layout are liable to be shut down.

The expense of selling small heating units by means of personal calls by manufacturers' salesmen is exorbitant. It is, however, entirely feasible for the sales force of the electric utility to sell these devices. For example, it can easily be understood that the profit to the manufacturer from a direct-to-user sale of a $2.00 strip heater will seldom even equal the sales cost. Yet, this same strip heater will bring, as a conservative estimate, $5.00 annual revenue to the electric utility at 1c. per kw-hr.

Those of you representing the smaller municipalities are no doubt personally quite familiar with the local industries and heating processes which they carry on. You are, therefore, in a position to personally make suggestions in regard to the use of electric heating devices. The electrical manufacturer will gladly supply the services of a qualified engineer whenever you feel that such services will be of assistance to you.

In the larger centres, it is recommended that a simple survey be made of all or part of the local industries to determine the potential applications available for the various types of small units. This survey might well be made by a university student temporarily employed during the summer months or by the regular staff of "Power Salesmen". From the data obtained during the survey, a simple mailing list can be made of the responsible parties in the different customer organizations and the types of devices which they can use. The manufacturer will gladly supply literature illustrating and suggesting uses for the different devices, which literature you can mail to your prospects at intervals with a short letter commenting on the advantages of using the devices. The larger manufacturers maintain and operate mailing lists on a national basis and periodically send out literature to prospective users of these devices. Similar action by the electric utility, supplemented by calls by Power Salesmen help to keep fresh in the mind of the prospect the fact that electric devices are available to simplify his heating problems. Manufacturers' representatives have found numerous cases where industrials have incurred great expense to install fuel-fired heating equipment, simply because they did not know that electrical equipment was available, which could be installed at much lower first-cost, and which could be operated more economically and give greater satisfaction.

A number of Canadian electrical manufacturers have for years followed a policy of developing the market for these units by advertising in trade

journals, circulating among prospective users. These manufacturers are continuing this type of advertising without curtailment at the present time.

One electrical manufacturer has gone a step further and has prepared a catalogue in which he illustrates a large variety of these small industrial electric heating devices, tells where and how they should be used, gives the dimensions, the catalogue numbers, the prices, instructions how to install, recommends the type of control and gives data by which the user can calculate the number and the rating of units required and can order them by mail. This manufacturer is distributing this catalogue to interested parties in industrial concerns throughout Canada. He will gladly supply additional copies to electric utilities and suggests that they make certain that each prospective user on their lines is provided with a copy.

Selling by samples is age-old and has always been highly successful. One manufacturer has prepared a small kit containing a number of representative and popular small electric heating devices. These kits may be procured by utilities for purposes of display.

A film slide entitled "Spots of Heat for the Industrial Plant," has been prepared especially for the Power Salesmen's use. With this slide and a projector, which can be secured at small cost, the Power Salesmen can quickly and convencingly illustrate to prospects the application for small electric heating units and show them how to make the installation.

As an example of the success that can be met with in selling these units your attention is drawn to the fact that of the 100 daily and semi-weekly newspapers in Canada who can economically melt their stereotype metal with electric heat, 27 have during the past five years installed electric melting equipment totalling more than 2,000 kw. connected load and consuming more than 3,000,000 kilowatt-hours per year.

DOMESTIC WATER HEATING

Throughout this discussion, capacities are given in Imperial gallons.

The National Electric Light Association appointed a water heating committee in 1928 to determine how faster progress could be made in the sale of water heater service in the U.S. During its three years of labour, this committee conducted tests in different parts of the country and made 30,000,000 calculations, the results of which are set down in a report published in 1931. Most of these tests were conducted on factory-built, properly insulated tanks. The tests were confined to heaters with unrestricted energy supply, as the number of controlled or off-peak installations was at that time too few to permit complete investigation. Tank capacities tested varied from 8 to 50 gallons and element ratings from 1 to 6 kw. In order that the data would be representative, tests were taken in the homes of individuals representing various callings, including teachers, mechanics, doctors, farmers, bankers, etc. The survey was restricted to dwellings having not more than three bath-rooms and no mercantile outfits were tested.

The lowest after-diversity demand occurred with heaters having two units, each rated 1 kw., one of which was operated thermostatically and the other manually. After diversity demand is defined as the actual demand in kilowatts of a group of heaters divided by the number of heaters. It was found that 44 out of 60 heaters tested in this group rarely used the manually operated element. The after-diversity demand of this group was 0.7 kw. per heater. These heaters did not give a complete hot water service, it being necessary to anticipate abnormal demand and turn on the manually operated unit. Complete hot water service is defined as that under which water at the desired temperature is always available at the tap, except under abnormal conditions for which the heater was not intended to provide. With complete hot water service, the lowest after-diversity demand was 0.9 kw. and occurred with heaters having two units, one rated 500 watts and located near the bottom of the tank, and the other rated 1,000 watts, located near the top, both controlled by thermostats. The average monthly consumption of these heaters was 354 kw-hr. or 4,250 yearly.

In general, it was found that the higher the kilowatt rating of the installation, the higher the after-diversity demand and the lower the energy consumption. The type of heater was found to have more effect on the energy consumption than did the energy rate, but a higher rate appeared to limit the number of heaters sold. It was found that the average prospect is willing to pay \$3.00 to \$5.00 per month for energy and to consume between 3,000 and 5,000 kw-hr. per year. The rate structure in Ontario easily meets these conditions.

The committee was unable to find a single satisfactory development of electric water heating, even with low rates, where the electric utility had not accepted the responsibility for sales development. One successful utility not only assumes sales responsibility but also offers conditions that insure co-operation. In this case, 15 per cent. is allowed for dealer sales. Dealers can purchase and install standard heaters at 30 per cent. discount and carry the account. In case the utility carries the account, the dealer receives but 25 per cent discount and is still happy.

The successful sale of real hot water supply is a specialty job, requiring more than usual ability, together with real knowledge of the worth of the service and the appliances needed to insure that service. The following are some of the basic conditions which are essential:

(*a*) Attractive low first payment and long terms must be available.

(*b*) Public acceptance must be created through an educational program.

(*c*) Sales force should be thoroughly trained and every prospect should be carefully analyzed.

(*d*) Complete hot water service should be stressed and intermittent use of the heater discouraged.

(*e*) Installations should be carefully supervised by an especially qualified person.

(*f*) Particular attention should be paid to piping. Electric water heaters should never be connected to circulating piping systems.

(*g*) The temperature of the hot water delivered to the faucet should not be less than 130 deg. fahr., and need not exceed 140 deg. fahr.

Under present-day conditions, the majority of central station load curves have distinct peaks and valleys. Controlled electric water heating is of particular interest at this time as a means of filling in the valleys and thereby levelling the overall curves. Consideration must be given to the possibility that the off-peak load might at some time reach a point where a new peak would be created. In some foreign countries, they are already faced with this problem. For this reason, the subject is referred to in this discussion as "controlled" rather than "off peak" heating. In the case of an inter-connected system, of which there are several in Ontario, the system load curve should be considered.

Recent developments in electric water heater design have made available heaters that can be used equally well on either unrestricted or controlled services with high efficiency. These developments have made available heaters of a universal type, a most valuable feature being that if load conditions change, or it seems advisable to make any change in the rate system, no change in style of heater is necessary.

In general, with controlled service, the water heating equipment should be capable of providing complete hot water service with a 12-hour charging period, even though its immediate application may allow for a longer period. An alternative method which reduces first cost is to use equipment of smaller storage capacity, with a longer charging period, and then should it become necessary later to shorten the charging period, install a mixing valve and charge the water to a higher temperature. Charging to a higher temperature increases the heat losses from the tank and tends to offset the saving in the first cost of the equipment.

For controlled service, dependable time-controls, both self-winding and synchronous, are now available at practical prices. A peak limiter is available which automatically disconnects the water heater when the electric range load reaches a predetermined value. The newly developed carrier current control, by which any number of water heaters can be connected and disconnected at will by an operator at a central point, appears to offer an ideal solution of the time control problem.

Time controls should always be installed on the service side of the switch. This eliminates the necessity of resetting the control in event of the occupant opening the main switch when vacating the premises for a time.

Water Used

The amount of water used and the times at which it is used have long been the subject of discussion, with the result that there are probably more different opinions on these points than on any other phase of the water heating problem.

The figure of 16 gallons per person per day is quite commonly used in the field for estimating the size of heater. While the use of this figure will undoubtedly provide sufficient capacity in the majority of installations, it will provide excess capacity in many, as the average maximum water used per person per day was found to be 9.2 gallons in Alabama, 11.4 in Maine, 9.3 in Utah, and 7.7 in Illinois. Once the heater is purchased, it appears to be the natural tendency to operate it as cheaply as possible, even though in order to do this the quality of the service is sacrificed.

It is found that heaters rated 3,000 watts and over almost invariably become manually operated, no matter how many automatic controls are provided. With a heater of this type, it is possible to obtain an appreciable amount of hot water in the time the customer is willing to wait and he feels that no heat is wasted on account of keeping a full tank of hot water. Experience has shown that the energy consumption of an identical heater is considerably greater when operated automatically than when operated manually. With a modern immersion heater, only a relatively small part of this difference represents losses, by far the greater part being accounted for by the increased use of water. Experience has shown that with complete hot water service, the amount of hot water used in some instances is more than double that used when a manually operated heater only is operated.

Furnace Coils

If a furnace coil is properly designed, it will provide complete hot water service during the coldest part of the season. Since in Ontario the coldest part of the year coincides with the period of maximum demand on the power system, the furnace coil keeps the water heating load from being superimposed on the system's peak. It appears to be a well-accepted fact that, in general, the furnace coil accounts for approximately 20 per cent. of the total fuel consumption. A test made at Washington State College in a 9-roomed house with a 25 gallon insulated tank showed the coal consumption to be approximately 20 per cent. greater with the furnace coil connected than when disconnected with all other conditions likely to influence fuel consumption the same.

The use of the furnace coil is not recommended with modern, well-insulated water heaters without the use of an auxiliary tank. The heat intensity applied to the water is very high and causes excessive scale formation and corrosion. The coil and its separate storage tank should be connected in series with the cold water inlet to the insulated heater.

Heat Losses

The heat losses for any installation consist of the losses from the tank itself and the losses from the piping. The former may be reduced to a minimum by proper insulation. The piping plays a very important part in the overall heat loss and in some instances has been found to cause losses considerably in excess of the heat actually used in the hot water delivered to the user. No electric water heater should be connected to a piping system which permits circulation. All piping to an electric water heating system should be dead

ended. The size of piping should be a minimum. In general, a ½ in. pipe will take care of usual needs. Copper tubing, although higher in first cost, appears to be preferable to iron pipe because of its smaller mass and because it maintains its original internal diameter throughout a period of years, while iron pipe in some cases becomes choked, due to corrosion and scale formation.

Statistics indicate that only about 10 per cent. of the 630,000 wired homes in the Province of Ontario have electric water heaters. Figures available indicate that approximately 190,000 or 30 per cent. of these homes possess electric washing machines and it is reasonable to assume that an equal saturation of electric water heaters is economically justified. The average domestic water heater consumes approximately 350 kw-hr. per month. Adding an additional 130,000 water heaters throughout the Province of Ontario to bring the saturation up to that of the washing machine would result in an increased energy consumption of 318,000,000 kw-hr. per year, based on seven months' operation, and would bring in a revenue of $2,400,000 per year at ¾c. per kw-hr. The average after-diversity demand of low wattage water heaters supplying hot water service is about 0.9 kw. On this basis, the additional 130,000 heaters would result in 117,000 kw. of increased demand and a load factor of approximately 54 per cent. during the seven months of operation. The greater the percentage of these heaters operated on flat rate with consequent lower wattage, the greater the load factor and the lower the demand.

One condition which has undoubtedly contributed materially to the delay in attaining greater water heater saturation is the fact that until very recently there has not been available in Canada a satisfactory, factory-built, insulated and thermostatically controlled heater at an attractive price. Practically all that was available to the consumer has been the low wattage immersion unit and the high wattage circulation or side arm unit. The operation of the immersion unit in the standard range boiler without insulation is decidedly uneconomical. Many consumers do not realize this and as a result of operating tanks without insulation, are dissatisfied with the service received in comparison with the cost of the electricity. This dissatisfaction, when expressed to other potential users, constitutes a distinct detriment to the popularity of electric water heating. Consumers, in general, are under the impression that they must purchase the heater and procure an electrician to make the installation, also secure a plumber to supply the heat insulation and install it. Their natural reaction is that the cost of getting the job done may be more than they are prepared to pay for the equipment. Consumers are inclined to expect too much from the single unit, low wattage heater with 25 gal. tank operated on flat rate and to be disappointed at the slow rate of recovery after abnormal draw-off.

The situation in respect to the circulation or side-arm heater is not much better. In some of the larger centres, some of the Department Stores occasionally advertise an installed price, and one large Depart-

ment Store in Toronto has been very successful on this basis this season, but in general, the consumer believes that there are two items in his cost, namely, the price of the heater and the cost of the installation, the second of which is unknown until he either asks for an estimate or has the job done. Usually no attempt is made to insulate the tank when the circulation type heater is used. The operation of the heater invariably is manual and a demand for hot water must be anticipated and the heater turned on in advance. The mere fact that a 3 kw. circulation heater requires approximately one hour to heat enough water for a bath discourages the prospective buyer because of its slowness, when compared with gas or with a coal-fired unit, which, when properly operated, usually keeps a supply of hot water available.

These handicaps, together with the fact that the selling price of the water heater is relatively low in comparison with the sales efforts and specialized knowledge required, have deterred those who would ordinarily merchandise water heaters from making a sales effort comparable with that made on certain other home appliances which bring in less revenue to the electric utility than does the electric water heater.

The development of the factory-built, insulated and thermostatically controlled heater has elevated the water heater to a place among the major electrical home appliances. These heaters are being sold either completely installed or less installation in much the same manner as are electric ranges. They take their place on the display floor among the aristocrats of the appliance line and their mere appearance suggests to the prospect a convenience which is rapidly resulting in a pronounced public acceptance.

Your attention is directed to an article appearing in "Electrical World", dated July 11, 1931, by George F. Williams, Vice-President of the Central Maine Power Company, in which the success of that company in selling factory-built, properly designed water heating equipments was outlined. Low wattage units were decided upon as they involved small chance of upsetting company's policies as to peak load demands and causing any heavy increase in capital investment. Tanks of 42 gallons capacity, equipped with two units, one rated 500 watts and the other rated 1,000 watts, were decided upon. Total rating of 1,500 watts, minimized wiring cost for the customer and the demand on distribution transformers and secondaries.

620 heaters were sold in 20 months, which is approximately one heater per day. A technically-trained, mechanical engineer was employed to supervise the work, part of his duty being to inspect the piping in every home buying a heater and to cooperate with the local plumbers. These heaters use, on the average, more than 4,000 kw-hr. per year and each brings in a revenue of approximately $5.10 per month on an energy rate of 1.5c. per kw-hr. Of the 620 heaters, 10 per cent. were rated 3,000 watts and 3.5 per cent. were connected two in series, to provide 100 gallons capacity. The average installation cost for wiring and piping

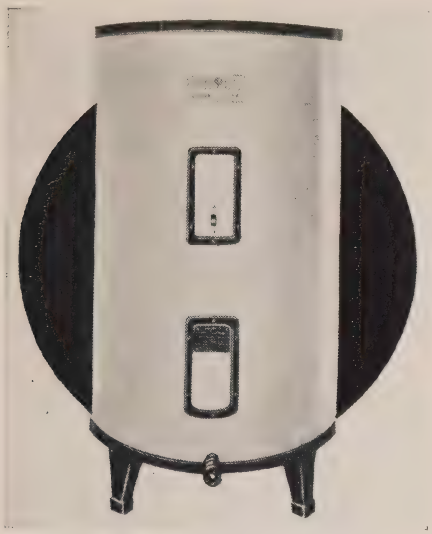


Fig. 1—A 25 gallon electric water heater.

was $28.26. The heaters were sold installed for $150.00 cash and $165.00 on time. After the original 20 months' experience, the price was raised to $199.50 installed.

These heaters show a load factor of 55 per cent. to 60 per cent. over a 24-hour period and the after-diversity demand per heater is approximately .9 kw.

Fig. 1 shows a heater of 25 gallons capacity. Fig. 2 shows a cutaway view. Note that the heating units are installed from the top and that the heated water rises in the central accelerator tube and is discharged at the top of the tank through a thermostatic valve which opens automatically when the water in the accelerator tube becomes heated. This heater, which we call the vertiflow, might be described as the de Luxe model, representing the optimum in hot water service. Note the built-in heat trap in the hot water line and the 4 in. of heat insulation. Two thermostats control the two heating units. The lower thermostat controls the low wattage base-load unit and the upper thermostat controls the high-wattage booster unit. The electrical wiring is concealed within the outer steel shell and the electric and water connections are made at the back of the tank. Fig. 3 shows a cutaway view of a 25 gallon plain storage heater. The placing of the unit in the side of the tank instead of in the accelerator tube, as in Fig. 2, permits lower manufacturing cost, at the expense of rapid recovery of hot water at the top of the tank.

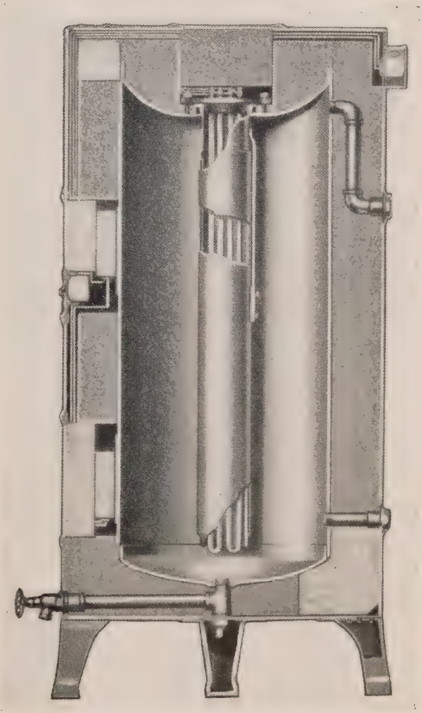


Fig. 2—Cutaway view of 25 gallon water heater shown in Fig. 1.

The vertiflow design in the 25 gallon size, with equal wattage, will give equal hot water service to the 42 gallon size in the plain storage design, when hot water demands are erratic and constant temperature at the tap is desired. On the other hand, where hot water demands are not periodically excessive, or where rapid recovery is not essential, the plain storage type gives satisfactory service.

In the 25 gallon size, the vertiflow model retails for less than $160.00 without installation, while the plain storage model retails for less than $125.00, both equipped with two units and two thermostats. Either design can be supplied with one or two units

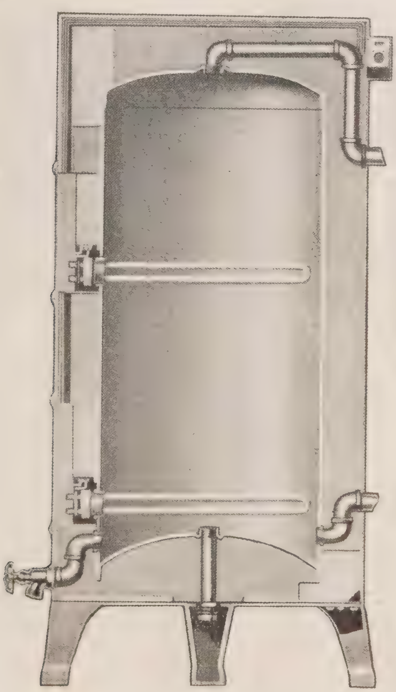


Fig. 3—Cutaway view of a 25 gallon plain storage water heater.

Fig. 4.—A 25 gallon electric water heater of cheaper design than that shown in Fig. 1.

and one or two thermostats, with consequent price reductions.

Fig. 4 shows a 25 gallon heater designed to sell at a lower price than the two models previously referred to

and consequently should be of interest to the buyers who cannot afford the higher priced models. In the latter model, the tank is more nearly the conventional design and is made of lighter gauge metal. The heat insulation is approximately 2 in. thick. Cold water inlet and hot water outlet are both at the top of the tank and no hot water trap is provided. Terminal boxes are provided on each heating unit and service connections are brought direct to the unit instead of to a common terminal box at the back of the tank. It is intended that the bottom unit will be in service continuously and thermostatic control is not provided for it. This heater is offered with the top unit controlled by a thermostat located immediately above it, or alternatively, without thermostat, but with a snap switch located on the top unit for manual control. The bottom unit may be operated on a flat rate service where flat rates are in favor and the top unit operated on the meter circuit. The purpose of the top unit is to provide rapid recovery and assure a constant supply of hot water at the top of the tank. Standard rating will be 500 watts for the bottom unit and 2,000 watts for the top. Top units rated 1,000 watts and bottom units rated 350, 660, 750 and 1,000 can be supplied as alternatives to the standard rating. This heater retails without installation at less than $80.00, with bottom unit only, and at less than $100.00 when equipped with both bottom and top units and one thermostat.

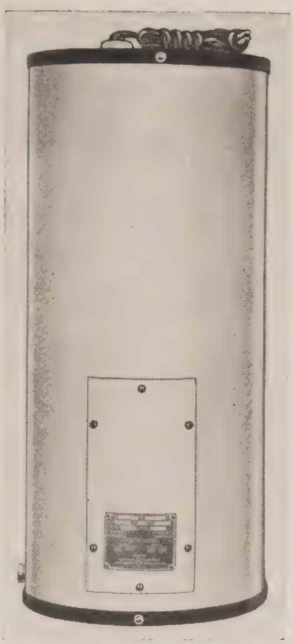


Fig. 5—An electric water heater of 4.2 gallons capacity

Fig. 5 shows a heater of 4.2 gallons capacity, provided with outer steel shell, 2 in. of heat insulation and thermostat. The heating unit is rated 1,250 watts and may be operated on either 115 or 230 volts by changing internal connections. This heater is ideal for summer cottages with pressure water supply, also barber shops, gasoline service stations and other commercial establishments. It is provided with a cord and plug and special electric wiring is not necessary. This heater retails at less than $50.00.

All of these heaters are made in Canada.

Association of Municipal Electrical Utilities

Report of Rates Committee.

At a meeting of the Rates Committee held in London, June 2nd, the matter of pre-payment meters was discussed. It was the census of opinion that the first cost of such a meter was too high for the result that we hope to accomplish. It was also felt that in normal times such a meter is not required and that a deposit with all contracts for tenants would solve the problem.

Neon sign billing was discussed. Your committee recommends that the volt ampere rating be used for the basis of billing and where demand metering is used a percentage of sign load be added to demand.

In connection with the Standard Interpretation of Rates the Committee considered the rewording of Clause No. 2. The words "will accompany" and "also a copy" be eliminated. The words now in Clause No. 27 reading "will be billed" changed to "may be billed".

It was moved by Mr. Sifton and seconded by Mr. Buchanan and the resolution adopted by the Committee that the above recommendation be forwarded to the Hydro-Electric Power Commission.

Members of the committee in attendance were Mr. Sifton, Mr. Yates, Mr. Peart, Mr. Buchanan, Mr. Perry, and Mr. Catton, Chairman.

Report of Committee on Research

Remote Control of Loads

The Commission's Laboratory has made a preliminary report describing the work done to date and recommending that the next step be an application of the system worked out in the laboratory to a specific case. It is felt that a trial installation would furnish operating experience which would guide future efforts.

Grounding

The Committee on Driven Pipe Grounds is continuings its valuable work in investigating ground conditions throughout the Province and methods of obtaining satisfactory grounds in rural localities. A large number of tests have been made and much work has been done in improving ground resistances. One method of accomplishing this, which has been tried, is to tie the anchor rod to the driven ground. This method was recently subjected to investigation. A series of tests were made to determine the possible hazard resulting from this practice. As a result of the measurements and the information obtained the committee unanimously agreed to the following resolution:

> "Moved that the Committee recommend that no further anchor rods be connected to ground rods and that such steps as are practicable be taken to disconnect the anchor rods which have already been connected."

The Grounding Committee is also investigating a ground factor composed of wire mesh which has been tried out extensively in New Zealand in localities where rock is near the surface.

Domestic Electric Water Heating

Further attention has been given to this subject and a comprehensive report has been prepared by the Laboratory department.

Standardization

The Commission is co-operating with the Canadian Engineering Standards Association in the preparation of many standards and specifications governing materials and practice. Among these may be mentioned work of radio co-ordination being carried on by a committee on the Canadian Electrical Code. The Commission has contributed to the deliberations of this Committee in co-operation with other inspection authorities, with the Bell Telephone Co., and with the Radio Branch of the Department of Marine, Ottawa. Present efforts are being directed to the collection of information and to the drafting of principles. When this work has been finished it should be of assistance to all branches of the industry.

News Item

The C.N.R. round-house and machine shop at the Canadian end of the St. Clair tunnel is now supplied by the Sarnia Hydro-Electric System. The load taken over by the Sarnia Hydro has 410 h.p. connected and a monthly demand of 275 h.p. Power is supplied at 550 volts, 3-phase, 25 cycles, from 3—75 kv-a., 2,300/550-volt transformers, and the lighting from 2—15 kv-a., 550/110-volt.

A Good Record

Recently the local office of the Commission at Cobourg received payment of the last outstanding account for service in connection with the Local Utilities in Cobourg which have been administered by the Commission since the purchase of the properties by the Provincial Government in 1916. The Water and Light Utilities were taken over by the Corporation at the first of this year and due course will be placed under local management.

The records show that over a period of 32 years, beginning April 1899, and ending December 31, 1931, every account owing has been collected. During this period the properties have been under the management of Jas. E. Skidmore who has carried on his duties on behalf of the following corporations controlling the properties.

Cobourg Water Works Co.
Cobourg Gas, Light & Water Co.
Cobourg Utilities Corporation, Ltd.
Hydro-Electric Power Commission of Ontario.

The operation of these properties without a single bad debt, over so long a period, is a record which reflects great credit on Mr. Skidmore and his staff and one which will challenge most, if not all, of the records of the public utilities in the Province.

A New Kind of Transformer

One of the most effective mind changers we've heard about in a good while is used at a certain stock yard. Some animals object to being driven along a chute—feeling, apparently, that their wishes are not properly respected. In such cases, an attendant simply touches the unwilling creatures with an electrical prod and they move along without further ado and ceremony, and with great alacrity.

One end of the prod is connected by a flexible lead to a bare overhead trolley wire, to a 110-volt supply grounded through a resistance. A cow, for instance, when prodded simply completes the circuit to ground, and receives a shock not severe enough to produce injury, but quite sufficient to transform stubborn resistance into willing activity.

—*The Electric Journal*

FURTHER CONVENTION TRANSACTIONS WILL APPEAR IN THE AUGUST NUMBER

THE BULLETIN

Published by

HYDRO-ELECTRIC POWER COMMISSION

of Ontario

190 University Ave.
Toronto

Subscription Price $2.00
Per Year

The Principles of Democracy

By Right Honourable Arthur Meighen, K.C., P.C., Commissioner, Hydro-Electric Power Commission of Ontario

(Address to Ontario Municipal Electrical Association and Association of Municipal Electrical Utilities at Bigwin Inn, Muskoka, June 24th, 1932.)

MR. Chairman, Ladies and Gentlemen, some weeks have elapsed since I was in a position to address my fellow citizens at any place. This opportunity comes after many months of devotion to tasks of a more personal nature, but I am glad, as I always am, to find myself face to face with citizens of our country and especially with men and women representative of the business and social life of the premier province of our land.

To find a topic not too hackneyed, and not too fraught with figures and dry facts is not an easy task. But my mind has turned to a subject raised in one phase of the discussion before this association yesterday and carried to me since my arrival by those who heard it.

I am not launching any attack on the special motion then under debate, but merely using the general subject, in an endeavour to lay before you a few thoughts on the tendency of the times and emphasizing a certain restraint which, I believe, the public of the world must exercise if the lot of humanity is to be rescued and elevated. There are many who casually, and I fear somewhat thoughtlessly assume that the principles of democracy, as they understand them, are sacred in themselves and cannot possibly be brought into play in the wrong place. They believe that they can never be extended too far.

This theory, it seems to me, animated those who yesterday felt that something further in the way of democratic management of this great enterprise, which we are all devoted to, would perhaps be in the interests of our province and the municipalities.

I feel that we should at this time reflect that democratic control certainly never extended in the world so far as it does to-day. Democratic control not only never extended so

CONTENTS

Vol. XIX **No. 8**

August, 1932

far, but it never expressed itself so directly and immediately over the whole universe. There are certain parts of the world where this practice has resulted in countries finding themselves in chaos and they have reverted to forms of despotism more severe and more oppressive than had been known for centuries. Italy went to Fascism. Russia went to Sovietism. In the one case individualism was retained, resplendent; in the other case all incentive to individual gain was gone.

This world to-day, after the application of these democratic ideas—after their application for many decades—finds itself in the most peculiar position. We look out the windows of our homes, no matter what land we inhabit, and we see Nature as glorious as of yore. We see all the gifts of nature more abundant than ever. We see everything at hand for the happiness and sustenance of man. We find, indeed, an abundance so great that we come hastily to the conclusion that there is too much of everything.

But, while Nature has done her part and denied nothing, this world, after the application of all these democratic ideas, and after the public, as we understand it, has had its say in almost every land, we find the hearts of men more distressed and discouraged than in many generations.

That fact alone is just worth while keeping in mind when we seek to think to the roots of things and to find whether or not, perhaps, we are wrong in extending these principles too far.

We look, for example, to the great country to the south. There, undoubtedly, the vast and heterogeneous mass of people have more immediate and direct voice, not only in the election of their representatives who determine policies, and all that is good, but in the actual administration of those policies by the several executives of the nation. There, democracy has insisted on this restraint and that, in the determining of this policy and that, by those elected to conduct public affairs to such an extent that when great difficulty and emergency comes they find themselves entangled in a mass of legalistic machinery. They can apply no restoratives. They can adopt no definite system or plan of extrication.

And while in their hands, largely, rests the key for the rescue of the people of the world from their present plight, they are utterly unable to turn that key and take the course which undoubtedly their intelligent population would direct were it able to have its way.

What I am trying to impress on you is this—don't think I am arguing against democracy—it is because I want democracy to survive that I

ask for certain principles and certain restraints to survive. Democracy is within its own sphere when it holds in its own hands the power to elect those whom it desires to govern but after there has been an election determined on principles of policy, leave the work of government in the hands of those elected.

Thus far democracy exercises its right, but when it extends beyond, and seeks, as in the country to the south, to interfere in the administration of policy, and in the management of great state businesses, then we are near the edge of the precipice over which more than one country already has gone.

What has been the great error of the last quarter century? What, more than all else to-day, is at the base of the troubles of our time? I know it is in the minds of most of you to answer: "The extreme terms of the Treaty of Versailles".

The war, which well nigh wrecked humanity, produced in the great masses of people of every land a spirit of vengeance and of hatred. Those feelings determined the courses of great men who sat in Paris following the Armistice and who framed the Treaty on which to-day the relations of nations rest.

The terms of those treaties were so extreme that they were impossible of fulfilment. The debt structures they raised between countries were such that they became out of all proportion to commodity values the world over, and therefore, out of all proportion of the power of the public to pay. In the strangle hold of those debts, the nations of the world struggle now.

Why were the terms of the Treaty of Versailles so drastic, indeed so fantastic? The ablest men of the world were there. Of the men who sat in Paris—some of them were on the side of moderation. The men who led the side of moderation were Lloyd George of England, and Woodrow Wilson of the United States. The leader of the other side was Clemenceau of France.

Now, what is the lesson? Lloyd George pressed strongly for amelioration of obligations to be paid by the defeated country. He was strongly opposed to the drastic terms which quite a number of the nations represented at Versailles wished to impose but the hand of Lloyd George was restrained by the dictates of Parliament. That Parliament pulled on the arm of Lloyd George as he sought to influence those associated with him at Versailles. They weakened his demand for such terms as would have put the world on a basis on which it could have lived.

In the antecedent election Mr. Lloyd George himself took a tremendous responsibility for a course of conduct which on his part is to-day the heaviest mortgage on his fame. In the subsequent contest he was defeated—not because he had been too extreme against the foes of the allies, but because in the opinion of the democracy of England, he had been too lenient.

And what of Mr. Woodrow Wilson? He, too, soon went down to defeat, not because he had been too exacting with Germany, but on the contrary because of the noblest endeavour of his life. He had sought to make the United States a partner in the League

of Nations, which, in his judgment, would forever end war. He, too, as you know, went down to defeat because of his tolerance and because of his broad and majestic plan of world redemption.

And the extreme Clemenceau—he, the protagonist of vengeance—Clemenceau, too, fell when the election came in France. He, too, fell, not because he had rivetted on Germany a Carthaginian Peace, but because he had refused to wrest from that vanquished land the Rhineland provinces for France.

Don't think that the errors of Versailles which are the starting point of the troubles of our time—don't think that those errors are at the feet of those who were in charge of public policy. Those errors were the errors of democracy itself, which failed to see far enough ahead and which held back the hands of those who would have adopted wiser counsels.

We find, at the close of the Napoleonic War that England was in the slough of financial despond. It seemed impossible that she should ever raise her head again in answer to her creditors for her debts. It was the wisdom of Wellington and Castlereagh, which determined what should be the treaty with the defeated country. But these leaders of 100 years ago were not so immediately influenced by the dictates of those by whom they were elected as were our leaders of 13 years ago. It would have been folly to have sought to visit on France the cost of the Great War. A policy of moderation was followed, which to-day would seem laughable in the sight of the Treaty of Versailles. Yet, that policy was founded on fair terms on which all nations could march together in the financial difficulties that followed and resulted in an accord between the two great leading powers of the world that has barred between them anything in the way of belligerency for 100 years.

I am speaking to impress these things only to let you see that it is possible that the will of the people is not always the voice of GOD. There is an area in which the public should be asked to take the responsibility even though they may within that area be wrong. Appeal to the public on great principles. Let the public determine policies which shall be followed and then leave to responsible authorities of the country the mapping out of the administrative course and the putting of those policies in effect.

When the principles of democracy are carried beyond that and when we seek, as in the United States, to elect our representatives and then, as in various states of the Union and in some parts of Canada, to have referendums here and there, and even to elect judicial officers we are launching on a course from which disaster only can come. We are imperilling the democracy we seek to save.

No, we don't want in this country any swinging away from those sound and tried principles on which British Democracy is founded.

Let us seek to apply some of these principles in the work we have to do in the limited sphere of Hydro. The great fact which stands as a tribute to the founders of this system is that

they recognized how far it should be democratic.

What is the whole basis of the organization? The basis is that the Hydro Commission is appointed by the Government, which represents the municipalities. That Government stands as answerable for all Hydro's capital expenditures. This money comes from the Government as banker of the enterprise. The municipalities elect local representatives for local administration, but upon this central body rests the responsibility and the power to determine the application of all funds of the enterprise. And because of that system, Hydro has succeeded instead of having failed.

The Government of this province is answerable to the people of the province and provides money on credit of the municipalities. Because that system has been followed, we are where we are to-day. We face this depression with $115,000,000 of reserves in the trying financial difficulties of our time.

Where would Hydro be now if it were answerable to the immediate whims of popular fancy? If these reserves had not been set up we would to-day find ourselves in the same morass as that in which we to-day see many businesses of our country floundering. We would find ourselves unable to weather the storm which rages around every enterprise, public or private.

When you do honor to the founders of Hydro, don't do honor only for the vision they had of bringing light or power into every home of this province, but do honor as well to them for having laid the financial foundation sound and true, for having fortified it, and seen to it that those who had put up the money were in a position to supervise great policies.

I was talking a day or two ago with the head of one of the largest firms in the world and he stated that he knew of no public enterprise and of very few private enterprises which were fortified financially just now as was the Hydro of Ontario (applause).

Therefore, let us raise our hats in honor to those who laid down the scheme of this organization and loyally adhered thereto. If it were not for them we would not be in our present happy position.

I know you are all supporting Hydro. I have sought at other times to defend the actual administration of your trust at the hands of this Commission. I don't feel like doing so now—it might carry me into territory lately traversed by judiciary authority. But my confidence has not been impaired one jot or tittle by any events of the last few months and it will be a proud day for myself and my colleagues in the Commission if, from the hands of those to whom is entrusted the inquiry, there comes a vindication such as has been our experience in days gone by and such as every commission has a right to expect if it does its duty, as we feel this commission has done.

I, therefore, close my short talk to-day by asking you to think mainly of the basic central principles around which your enterprise is built. Don't allow sacrilegious hands to be laid upon them. Don't allow what is

fundamental and vital to be impaired merely for what is fanciful or ephemeral. If those words are not forgotten there will be no great harm done to the Hydro organization of this province (hearty applause).

Ontario's Unique Electrical Service

The Advantages to Industry and Commerce offered by the Municipally-owned Electrical Undertaking Administered by the Hydro-Electric Power Commission of Ontario

(As Published in the Imperial Conference and Industrial Power Number of Electrical News and Engineering.)

THOSE attending the Imperial Conference, as well as those whom they represent, will have to give consideration to matters affecting the costs of manufactured products. In the intense competition that exists for markets, all of the factors entering into the cost of production merit the closest attention. An important element with which the industrialist has to reckon is the character and cost of electrical service, a commodity that has become a necessity in the modern commercial and industrial world.

The interest the industrialist has in electrical service is by no means confined to the use of electricity for power purposes. The welfare and comfort of his employees is a matter of prime concern, and thus where electrical service for domestic and commercial purposes, as well as for municipal uses, can be supplied at relatively low cost, the domestic burdens are lightened and the general status of living conditions is raised.

A quarter of a century ago, leading manufacturers and public-spirited citizens of the Province of Ontario, foreseeing that their Province with its bountiful natural resources was destined to take a prominent place in the world of industry and commerce, became greatly interested in the matter of low-cost power, and as a result the Hydro-Electric Power Commission was created and Ontario's great municipally-owned electrical enterprise came into being.

It is not necessary here to present an historical survey of the undertaking.* It is sufficient to state that it was concluded that the citizens of Ontario could not do better than develop their large waterpower resources in the common interest. Special provincial legislation was enacted to enable the cities, towns and other municipal organizations of the Province to co-operate for the purpose of creating a transmission network over which hydro-electrical energy could be transmitted to various centres. Underlying the whole programme was the principle of providing the service at cost.

* An illustrated pamphlet entitled "The Hydro-Electric Power Commission of Ontario, its Origin, Administration and Achievements" may be obtained from the Head Office of the Commission, 190 University Avenue, Toronto.

Uniform standard accounting systems ensure that each class of service —domestic, commercial light, power, etc.,—produces a revenue proportionate to its cost; and tariffs or rate schedules for retail service are designed to ensure, as nearly as practicable, that each consumer is charged with the actual cost of the service he receives. The general taxpayer does not bear any portion of the costs, either of industrial power or of domestic or commercial services, which are entirely met by those who utilize the service.

Rapid Growth of Undertaking

The intial capital expenditure to serve some twelve municipalities with power purchased from existing developments at Niagara was about $3,600,000. To-day, the capital investment in the systems of the Commission totals some $267,500,000 and the associated municipalities have invested in distributing systems and other local assets about $105,500,000 or a total investment in the undertaking of $373,000,000. During the same period the financial reserves have been continuously strengthened and now total for the Commission and municipalities more than $115,000,000.

The Commission commenced to supply power in 1910 with an initial load of less than 1,000 horsepower. This has grown until the peak load supplied by the Commission has already exceeded 1,250,000 horsepower and provisions have been made to take care of a future load of about 2,000,000 horsepower.

The Commission, on behalf of the co-operating municipalities, owns and operates 38 hydro-electric developments ranging in size from the great Queenston-Chippawa development of 550,000 horsepower down to small developments of a few hundred horsepower. These are strategically situated throughout the settled districts of the Province, and their output is supplemented by power purchased under long-term contracts.

At the end of the fiscal year the number of municipalities served in Ontario by the Commission was 721. This number included 27 cities, 93 towns, 263 villages and police villages and 338 townships. With the exception of 12 suburban sections of townships known as voted areas, the townships and 86 of the smaller villages are served as parts of 167 rural power districts.

Rural Electrical Service

During the past few years very substantial progress has been made in Ontario in the field of rural electrification. Practically all rural electrical service is now given through rural power districts which are operated directly by the Commission. There is now rather more than $15,507,000 invested in the rural power district systems established by the Commission. Towards this rural work the Ontario government, pursuant to its policy of promoting the basic industry of agriculture, has, in the form of grants-in-aid, contributed 50 per cent. of the costs of transmission lines and equipment, or some $7,677,000. A total of 8,197 miles of transmission lines have been constructed to date, of which 1,470 miles were constructed during the past year. There are now more than 55,000 customers supplied in the rural power districts.

Growth of Municipal Utilities

The progress that has marked the co-operative enterprise has been equally characteristic of the associated local electrical utilities. The standard accounting system employed in these utilities enables comprehensive comparisons to be made of the results achieved over a period of years. Table I illustrates the growth that has taken place during the past decade.

From Table I it will be seen that whereas the assets of 1931 are more than three times those of 1921 the liabilities of 1931 are but little more than twice those of 1921. During the same period the local utilities' reserves have increased nearly sixfold and the surplus is now four and one-half times as great as in 1921. The total annual revenues of the municipal electric utilities last year were $31,658,000 as compared with $10,982,000 in the earlier year, or nearly three times as great.

Many Municipal Utilities Debt Free

So successful has been the operation of the local Hydro utilities that, notwithstanding the low rates for all classes of service, most municipal utilities have accumulated substantial reserves and paid off large portions of their indebtedness. Out of 275 urban municipalities to which the above table relates, some seventy have, in quick assets such as cash, bonds, accounts receivable and inventories, sufficient resources to retire the total outstanding liabilities and therefore may be considered as being free from encumbrance. Others have made extensive additions to plant equipment entirely out of accumulated surplus without having to borrow new capital. Furthermore, it should be noted that in their payments to the

TABLE I.

GROWTH OF ONTARIO MUNICIPAL UTILITIES

	1921	1931	Increase %
Municipalities included	215	275	—
Total assets municipal electric utilities	$40,112,000	$125,538,000	214
Sinking-fund equity in Hydro Commission's systems	796,000	20,103,000	2,430
Total liabilities	25,434,000	52,199,000	106
Reserves	6,292,000	35,544,000	465
Surplus (debentures paid, local sinking fund and additional operating surplus)	8,386,000	37,794,000	350
Percentage of net debt to total assets	64.7%	44.1%	—
Revenues: Domestic Service	3,149,000	11,479,000	265
Commercial Light Service	1,852,000	6,278,000	240
Commercial Power Service	3,895,000	9,568,000	146
Total (including street lights and municipal power)	10,982,000	31,658,000	188

TABLE II.

CHARGES FOR ELECTRICAL SERVICE IN REPRESENTATIVE ONTARIO MUNICIPALITIES

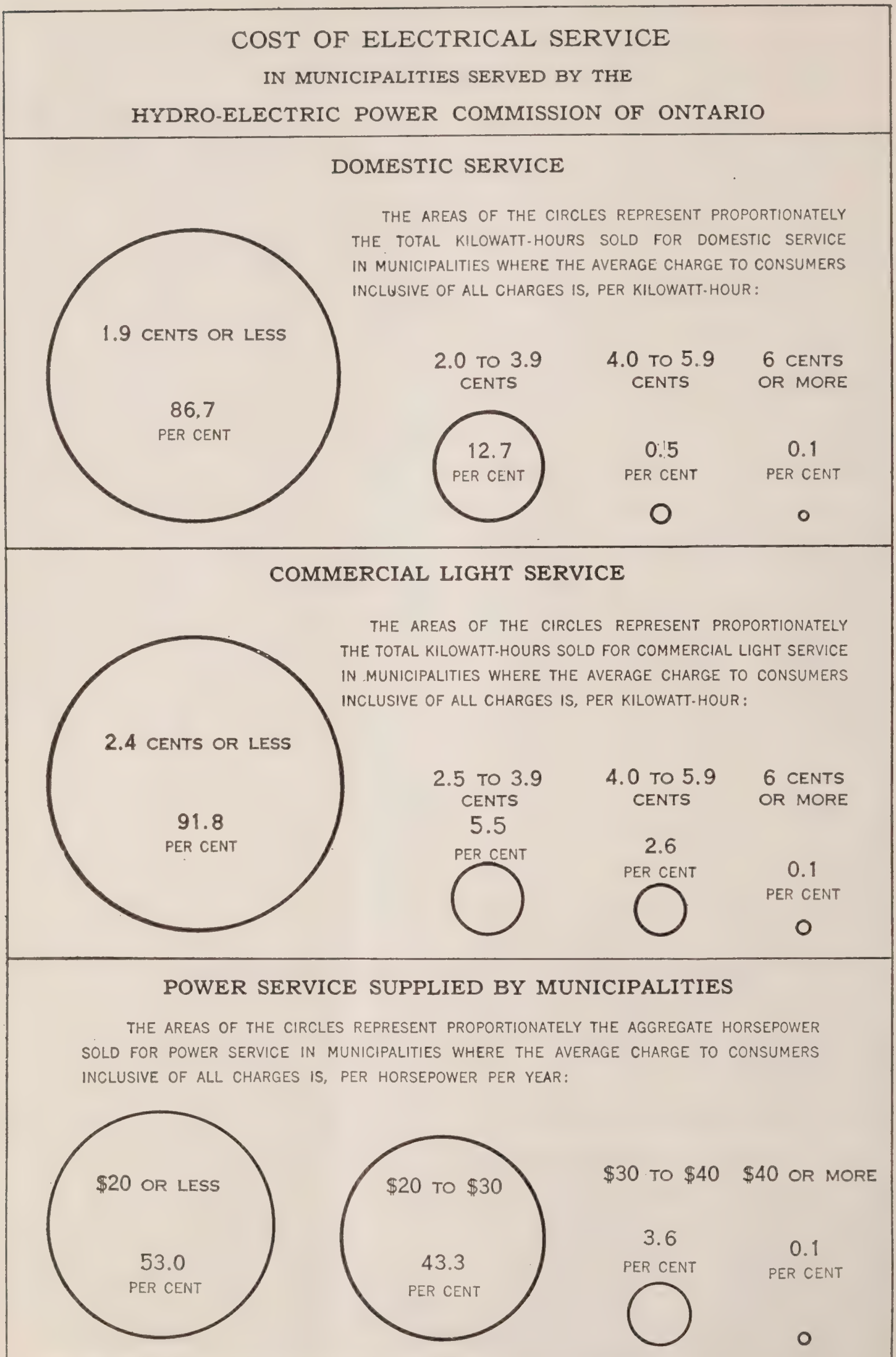
Municipality	Population	Approx. transmission distance from nearest gen. station	Average net charge to consumers inclusive of all charges: Dom. service cents per kw-hr.	Com. light service cents per kw-hr.	Power service dollars per h.p. per year
Toronto	606,370	78	1.5	2.3	23.70
Hamilton	144,529	53	1.4	1.3	10.94
Ottawa	125,496	1	0.9	1.6	10.80
Windsor	70,031	238	1.6	1.8	21.00
Kitchener	30,274	95	1.7	1.7	19.15
Oshawa	25,550	75	2.6	2.8	21.96
Peterborough	22,487	2	1.8	1.9	18.21
Guelph	20,393	75	1.7	1.6	16.65
Sarnia	17,003	205	1.9	1.8	28.13
Galt	13,752	92	1.9	2.0	18.11
Owen Sound	12,778	32	1.8	1.7	16.34
Woodstock	10,898	94	1.6	1.6	15.72
Waterloo	8,389	96	1.6	2.1	16.50
Barrie	7,166	48	1.3	1.7	17.83
Preston	6,171	86	1.8	2.3	18.12
St. Marys	4,073	133	2.0	2.6	22.57
Picton	3,146	33	2.1	2.3	16.91
Waterford	1,091	94	1.6	1.7	18.23

Commission for power at wholesale, the municipalities are steadily building up a substantial equity in the co-operative generating and transmitting equipment of the central organization.

Low Costs of Electrical Service

Now, the object of outlining these facts is first, to show the substantial character of the undertaking by means of which electrical service is made available in the Province of Ontario; and second, to lead up to a statement representing what the prospective manufacturer may expect in the way of power service, and also what his employees—individual consumers—may expect in the way of general electrical service.

Table II presents average costs for domestic, commercial and power services in a number of representative municipalities which have been selected having respect to their various distances from the source of generation of the power; also, to the sizes from the standpoint of population. Moreover, the selection includes many representative centres viewed from the standpoint of their possessing varied industries.


COST OF ELECTRICAL SERVICE
IN MUNICIPALITIES SERVED BY THE
HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO
DOMESTIC SERVICE
THE AREAS OF THE CIRCLES REPRESENT PROPORTIONATELY THE TOTAL KILOWATT-HOURS SOLD FOR DOMESTIC SERVICE IN MUNICIPALITIES WHERE THE AVERAGE CHARGE TO CONSUMERS INCLUSIVE OF ALL CHARGES IS, PER KILOWATT-HOUR:
1.9 CENTS OR LESS
86.7 PER CENT
2.0 TO 3.9 CENTS
12.7 PER CENT
4.0 TO 5.9 CENTS
0.5 PER CENT
6 CENTS OR MORE
0.1 PER CENT
COMMERCIAL LIGHT SERVICE
THE AREAS OF THE CIRCLES REPRESENT PROPORTIONATELY THE TOTAL KILOWATT-HOURS SOLD FOR COMMERCIAL LIGHT SERVICE IN MUNICIPALITIES WHERE THE AVERAGE CHARGE TO CONSUMERS INCLUSIVE OF ALL CHARGES IS, PER KILOWATT-HOUR:
2.4 CENTS OR LESS
91.8 PER CENT
2.5 TO 3.9 CENTS
5.5 PER CENT
4.0 TO 5.9 CENTS
2.6 PER CENT
6 CENTS OR MORE
0.1 PER CENT
POWER SERVICE SUPPLIED BY MUNICIPALITIES
THE AREAS OF THE CIRCLES REPRESENT PROPORTIONATELY THE AGGREGATE HORSEPOWER SOLD FOR POWER SERVICE IN MUNICIPALITIES WHERE THE AVERAGE CHARGE TO CONSUMERS INCLUSIVE OF ALL CHARGES IS, PER HORSEPOWER PER YEAR:
$20 OR LESS
53.0 PER CENT
$20 TO $30
43.3 PER CENT
$30 TO $40
3.6 PER CENT
$40 OR MORE
0.1 PER CENT

A graphic summary of the average costs to consumers of the local utilities in urban municipalities served by the Commission is presented in the accompanying diagram. It will be seen that of the total kilowatt-hours sold for domestic service more than 86 per cent. is sold in municipalities where the average charge to consumers inclusive of all charges is 1.9 cents or less per kilowatt-hour. Similarly, for commercial light service it is shown that more than 91 per cent. is sold in municipalities where the average charge to consumers for this service is 2.4 cents per kilowatt-hour or less. For retail power service supplied by the municipal utilities, 53 per cent. is sold in municipalities where the average charge to consumers, inclusive of all charges, is $20 or less per horsepower per year and less than 4 per cent. of the power service supplied by municipalities was sold in municipalities where the average cost exceeded $30 per horsepower per year.

The large annual consumption *per domestic consumer* is a striking feature of Hydro service. Of the 79 cities and towns with populations of 2,000 or more—in which over 85 per cent. of the domestic consumers of the undertaking are served—no less than 52 have an average annual consumption per domestic consumer in excess of 1,000 kw-hr.; of these 27 have an average annual consumption per domestic consumer in excess of 1,500 kw-hr., and 11 have an average annual consumption per domestic consumer in excess of 2,000 kw-hr. The rate schedules designed to reflect the principles of "service at cost", automatically encourage liberal use of the service.

Advantages for Industrialists

The policy and practice of the Commission is to make as widespread and beneficial a distribution of electrical energy as possible, and to extend to every community that can economically be reached by its transmission lines the benefit of electrical service. Owing to the large quantities of power transmitted and to the principle of service at cost, power is made available in Ontario even at distances up to two hundred miles or more from the generating plant with relatively small additional cost per horsepower. This policy enables industries to select situations in accordance with their individual preferences, having regard to the varying influence of such factors as proximity to raw materials and to markets, cost of land, transportation facilities for distribution as well as for export, and availability of suitable labor supply.

In connection with the subject of employees, it should be appreciated that many of Ontario's municipalities have for years possessed varied industries which have become well-established and which are manned with experienced and competent workmen. Many own their homes and their children are growing up with good education, rugged physique and familiarity, it may be said, with an industrial environment. It is obvious, therefore, that those seeking to establish new industries will find that one of the prime factors essential to success—namely, an advantageous supply of desirable labor—already exists in the Province of Ontario.

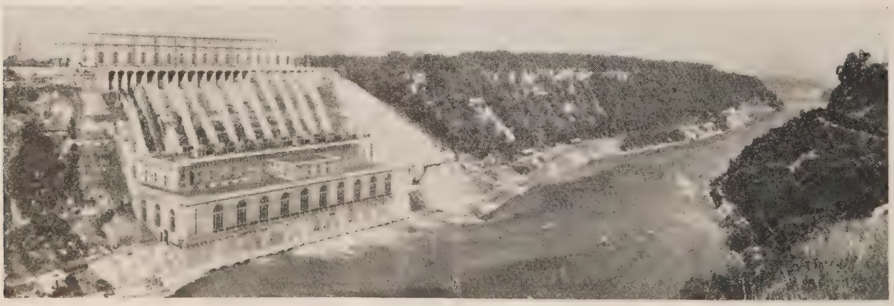
Retail Power

In the urban municipalities supplied with power by the Commission, industrial consumers served at retail and covering a wide range of diversified manufacturing activities number about 12,000. For manufacturers requiring larger blocks of power, each set of circumstances is considered on its own basis and power is supplied on behalf of the municipalities directly through the Commission under special contract. As in the case of retail power supplied by the individual municipal utilities, power sold direct by the Commission is supplied at the lowest possible rates consistent with its cost. Pulp and paper mills, mines, and electro-chemical undertakings manufacturing such products as aluminous abrasives, chemical fertilizers and industrial gases comprise the chief industries whose special requirements are met by direct contracts with the Commission.

Ontario's Position

The Hydro-Electric Power Commission of Ontario has now been in existence nearly a quarter of a century, and the anticipations of its founders with respect to industrial development in Ontario that would become possible with the provision of ample supplies of low-cost power have been more than justified. In the last year for which complete data are available—1929—Ontario's agricultural production was $340,000,000; its forests yielded $90,000,000 and its mines $117,000,000. Impressive as are these main items of primary production, the net production of Ontario's manufacturing industries in 1929—that is, the value added to raw materials by industrial processes—greatly surpassed all other sources of wealth creation in the Province, reaching more than $1,000,000,000. The provision of economical power supplies has been a material factor in the attainment by Ontario of the advanced industrial position the Province, with its population of 3,400,000, now holds.

As in other spheres of activity, British capital has played an important part in the development of some of Canada's water powers. It is believed that no similar territories in the world are better supplied with hydro-electric power and light than are those served through the Hydro-Electric Power Commission of Ontario. Those interested in obtaining hydro-electric power for their industries or for use in the homes of their employees will find both the provincial and municipal authorities, as well as the Hydro-Electric Power Commission of Ontario, ready to cooperate in furnishing electrical service at the lowest possible cost.



The Importance of Record Control to Executive Management

By Henry J. Johnson, Remington Rand, Incorporated, Buffalo, N.Y.

(Presented to Association of Municipal Electrical Utilities, at Bigwin Inn, Muskoka, June 24, 1932)

MANAGEMENT cannot function efficiently without complete and adequate records to guide and influence decisions. Many executives have until recently considered records and books necessary evils rather than indispensable aids in the conduct of business. It has been my observation that there is usually a reason for every condition. The reason for records having been in ill repute is that they have failed to accomplish what was expected of them. They have failed to sound the warnings of danger when trouble really existed. They have failed to provide the controls that are so necessary and vital in guiding those responsible for both the success and failure of every enterprise. The failure of records to provide the necessary controls can usually be charged to the fact that they have not been properly designed or their functions carefully planned.

Accounting records are an absolute prime necessity to the successful operation of any organization. Record control is to executive management what guide posts are to a traveller in new and strange territory, because just as the traveller is unable to tell what he will have to face just around the next corner or just over the next hill so the business executive must be prepared for all emergencies with definite information covering past experiences. Guesswork must be eliminated and all operations based on the firm foundation of accurate knowledge.

We often hear the charge made that bookkeeping costs are too high and this fact can very often be substantiated, because it is true that in too many instances accounting methods have not kept pace with the improvements and advances that have been made in construction, generation, distribution and utilization methods. Bookkeeping is defined as an art and accounting is defined as a science. The bookkeeper records the fact by the method and on the forms as designed by the accountant. These facts must then be interpreted by the accountant to the management in the form of reports and statements. The accountant must occupy the same position with respect to accounting control that the engineer does to plant operation and management. If plant workmen had been allowed to perform the functions and duties that belong to the engineer to the extent that bookkeepers have been permitted to fill the place that belongs to the accountant, then modern plant management would still be an unknown quantity.

The opinion still exists that complete accounting systems are complicated to operate and require highly trained personnel. Quite to the contrary is true, because in place of the

multiplicity of forms, duplication of effort and the unnecessary transcription of information which is to be found in the average system in use to-day, we have a method of procedure clearly outlined and well defined which is easy to follow and which eliminates errors and confusion. Control accounts instead of requiring more effort actually reduce the amount of work and simplify the entire procedure. They insure accurate reports promptly rendered, while the information is still of value. Reports that are not accurate and reliable are like road signs and guide posts that direct you the wrong way. They are worse than none at all—even guess-work would be safer, because you would have at least a fifty-fifty chance of being right. It is absolutely impossible to insure accurate reports without control accounts. Practically all mistakes made by the operating executive are due to either a lack of information or to reports that were not complete, accurate, or promptly rendered.

The question is often asked—Why are controls necessary and what can they accomplish? The answer is simple:

First:—From the standpoint of public relations and good will, it is very essential that any error or discrepancy that may exist in any customer's account be detected and corrected before it is discovered by the customer. This is impossible without controls. There is nothing that destroys public confidence in commercial, industrial or public institutions with whom they may deal as much as errors in their account, and as soon as one error has been discovered, they become very skeptical concerning the accuracy of all future transactions.

Second:—The most effective way to insure work of the highest quality from the clerical personnel is to provide some means for accurately measuring the kind of work done by each individual and definitely fixing the responsibility for errors. It is impossible to do this without the use of control accounts. It is human nature to become careless, unless we know that an accounting must be rendered for the quality of the work we perform. It is likely to create the feeling among even the most conscientious clerks that they receive no more credit or recognition for their services than other clerks in the same office who are less conscientious and who may turn out an inferior quality of work. Proper control accounts will definitely reveal the exact conditions, give credit where credit is due, and place the blame and responsibility for poor work where it belongs.

Third:—All records must be audited periodically. Unless controls are maintained, it is impossible for the auditor to certify as to their accuracy. Through the use of proper controls, an auditor can complete his work in very much less time and in his report make positive statements concerning the accuracy of the records. This is especially important with public institutions similar to the various hydro-electric systems throughout the province. Public criticism and condemnation of what might appear to be carelessness and inefficiency is often unmerciful. There have been many instances when the honesty and integrity of public offi-

cials have been questioned, when, as a matter of fact, it was only carelessness, lack of control, or failure to detect conditions that needed attention. Nevertheless, conditions of this kind are often difficult or even impossible to explain to the satisfaction of the public and the press. The responsibility of the management is heavy enough and the load is difficult enough to bear without having to shoulder unnecessary criticism. There is no one factor that relieves a managing executive of as much anxiety as the certainty that all records are correct and all operations properly accounted for.

In public institution there is always political opposition to be taken into consideration. It may consist of opposition to the present management or to the public ownership and operation of utilities. I am convinced that there is no one factor that has provided more and better material to support such arguments than the lack of proper accounting and record controls. Lack of these important aids to executive management have often made many perfectly sound and logical situations extremely difficult to explain. Every executive should avail himself of every possible agency that will not only reveal every condition that needs attention, but that will also establish to the satisfaction of all interested parties the fact that the operation of the enterprise is thoroughly efficient in every way. Self-preservation is said to be the first law of nature and there is no better and more effective way to insure this in either private or public operation than to safeguard all functions through proper record control.

Operating Factors That Must Be Controlled

I will discuss briefly some of the major factors that must be controlled. The time allowed for this paper will not permit a detailed discussion of the records necessary for this purpose or of many elements that are very essential to a complete analysis of this entire subject.

Meter Control

It is very important that every meter owned by the utility be accounted for, either by meters in service or in stock. Then, the meters in service must be accounted for either as active or inactive. Next, the active meters must be accounted for, either as meters billed, or meters on which the reading could not be secured. Without these controls, many meters may become lost or stolen and many instances have come to my attention of customers using energy for several years without ever receiving a bill. This is not as likely to occur in small communities, because the meter readers are usually well acquainted with conditions and are personally familiar with every service location. It is, however, putting the burden of accuracy on a rather uncertain basis, because it opens the way to dishonesty. With these controls an auditor can very quickly make a verification and certify as to the accuracy of the records. It is also important that these figures be maintained in order to show all increases and decreases from month to month.

Billing Control.

It is very essential that proper billing controls be maintained in

order to insure all bills being rendered in accordance with the proper rates, connected load, and other special billing information. By classifying meters, according to class of service in each route, a proof may be secured that bills are rendered accordingly. The computation and correct extension of all bills should be proved by breaking consumption down into rates and steps, then multiplying the various totals by the corresponding rates to prove with the total of all bills as rendered. All rate and billing information should be shown on the meter reading sheet and periodically checked with customers' service record for verification.

The meter sheets should be housed in proper binders, securely locked in order to provide insurance against unauthorized changes or removal of sheets. It is also recommended that meter sheets be so designed that it is only necessary to change the name of the customer and thus make it possible to accumulate the complete record showing the performance of each meter for the period of time that it has been used at the same location. This eliminates the necessary transferring of meter number, sizes, specifications and previous readings. It greatly reduces the possibility of error and effects a saving in clerical time, because the name of the new customer can be entered in much less time than is required for changing the sheet and transferring all of the information. Furthermore, it shows that the account is opened for the new customer with the same reading that was used for rendering the final bill to the previous customer.

The majority of high bill complaints result from incorrect readings. This can be almost entirely eliminated by requiring the meter reader to compute and extend the consumption while on the customer's premises. If the consumption is found to be unusually high or low, he makes a verification before leaving and then initials the sheet to indicate that it has been done. This practice eliminates the necessity of making a special trip to verify the accuracy of the readings when questioned in the bookkeeping department.

Accounts Receivable Control.

Probably the most vital and important control to maintain is on accounts receivable. It is first necessary to determine the unit of accounts on which controls are to be maintained. In a small community, it is only necessary to establish one control covering all accounts, whereas in a larger organization accounts must be divided into districts, one district representing one day's reading and one day's billing. A control should be maintained for each district and each district balanced one or two days prior to the time of sending out the bills for the following period. This insures all arrears that are being brought forward on the new bills being correct. It also eliminates any peak load at the end of the month, or the end of the billing period. In addition to this, all controls are balanced when the outstanding is at the very lowest point.

A record is set up for each control unit and charged with the total of all unpaid balances being brought forward on the bills. It is also charged with the total of all bills rendered and credited with the daily totals of cash

receipts. Any corrections or postings made through the medium of journal entries which increase or decrease the amount of the outstanding balance are also posted to this record. The difference between the debits and credits, which should be extended daily, must equal the total of the unpaid accounts at any time. This control provides positive proof that all cash receipts have been properly posted, that no accounts have been lost, and that all charges have been properly accounted for. It also provides a comparison of outstanding balances with the previous month or the previous year in order to determine the conditions of collections

Control on Forfeited Discounts and Penalties.

All forfeited discounts and penalties should be set up as soon as all payments received during the discount period have been posted. The total of such items should be immediately charged to the accounts receivable control and credited to the proper revenue account. This provides positive control and insurance against the cashier failing to collect the additional amount or allowing the customer to pay the net amount after the discount period has expired. It makes it impossible for the cashier to make collections and fail to report them. This method also makes it unnecessary to analyze the cash each day to determine how much of the amount represents forfeited discounts or penalties. It insures accuracy, eliminates the possibility of any irregularities, and reduces the clerical effort.

Analysis and Classification of Revenue.

All revenue should be analyzed, classified and controlled by rates and classes of service. This will not only make it possible to determine the trend, but also the fact that the rates charged are adequate to pay operating costs.

Controlling Inactive Meters.

A large investment is often tied up in inactive meters. Records should be set up to automatically control all idle meters according to length of time that they have been out of active service. It has been found that it is generally not practical to leave meters in vacant premises for more than six months, because experience shows that if they have been vacant for this length of time, that they are likely to remain vacant for an indefinite period. It has also been found that many meters are lost or destroyed, unless controlled in this manner and removed accordingly. Certain types of meters do not register accurately after having been idle for more than six months, unless properly cared for. This causes a substantial loss in revenue.

Control on Credits and Collections.

Credits and collections are rapidly becoming one of the most important problems with which the public utility executive is faced. The collection costs and losses through bad debts represent one of the biggest factors in the commercial cost classification. There is no problem that is more vitally connected with the important question of public relations. The most practical solution that has been found to this problem is the installation of a complete customer history record. This record will show the number and frequency of changes

in address, number and frequency of delinquent notices, cut-off notices and actual cut-offs for non-payment of bill. In addition to this, it is a complete record of worthless checks received, merchandise repossessed for non-payment, and previous unpaid final bills. This record should also show security deposits and guarantors, in order to provide positive control against the refunding of deposits until all final bills have been paid, and also to insure no final bills being charged off, if a deposit is being carried. Strange as it may seem, both of these conditions are very common occurrences. On an installation which is being made at the present time on approximately 40,000 accounts, at least $20,000 will be recovered in this way during the period of the installation. In addition to serving as the control on credits and collections, it is also a complete alphabetic index to all customers. This record makes it possible to determine the proper amount of cash deposit to be required and to guard against the extension of credit to customers whose record does not warrant it. This record makes it possible to transfer final bills from the old account to the new account. Experience proves that from 80 per cent. to 90 per cent. of all final bills are issued to customers who are merely moving from one address to another within the city. It is, therefore, unnecessary to have collectors make personal calls for the purpose of making these collections. Actual experience shows that during the period of installing a record of this kind and checking inactive and bad debt ledgers, that as much as one dollar per meter which had already been charged off or was considered doubtful, has been identified and recovered. This would prevail in larger cities to a greater extent than in smaller towns. A record of this kind also guards against antagonizing certain customers through undue or unnecessary pressure in connection with collections. I refer to customers whose payments are usually prompt. This record provides complete information as to business or occupation of each individual customer, in order that the management may be guided accordingly in all dealings and contacts.

Controlling Material, Supplies and Merchandise Stock.

Complete and accurate records and controls are always maintained on cash. Expensive equipment is provided for the purpose of registering, recording and auditing all cash transactions. Yet, when cash is converted into material, supplies and merchandise, the control usually becomes very lax. Thousands of dollars worth of stock is kept without proper record control. Unless responsibility is properly established, proper records maintained, and adequate audits made from time to time, large amounts of material and supplies are never accounted for. Material is often used without charges being made to the proper operating or construction accounts. All of this can be eliminated through the use of proper record control. Purchase orders should never be issued without an accurate knowledge of past requirements which consequently result in a large reduction in inventories.

The purpose and object of all stock

effort is to decrease inventory, increase turn-over, eliminate obsolescence, limit the variety and number of items carried in stock, and at the same time insure sufficient stock on hand at all times to meet all normal requirements and reasonable emergency demands.

Distinction must be made between stock control records and stores accounting control records. The purpose of stores accounting control records, is to account for the value of material and supplies stock, and to balance with the total inventory as shown by the general ledger, but it is not the function of the accounting department to concern themselves with the various factors and elements of stock control as outlined above. The responsibility for maintaining proper stock conditions and controlling purposes must rest with the stores and purchasing departments. They cannot discharge this responsibility properly unless they are provided with records especially designed for the purpose.

An apparently satisfactory over-all turn-over does not necessarily indicate efficient control methods, or the uniform soundness of stock conditions. It may have been due to large construction projects, extensive maintenance operations, or unusual activity in one or two classifications. What might appear to be an excellent over-all turn-over might conceal a serious obsolete, destandardized, or over-stocked condition in several other classifications. Therefore, unless both inventory and movement of stock is analyzed by classifications, it is impossible to determine where improvement can be made.

Inventories of material and supplies, and resale merchandise, have always represented one of the most variable and difficult factors to control in the operation of a public utility organization. The investment has been too large, the turn-over too low, and the factor of obsolescence and damaged material has in many instances reached rather alarming proportions. Insurance, handling charges and storage space requirements have become unnecessarily large. These conditions are directly attributable to a lack of proper facilities for executive management control by classifications. The only manner in which this operation can be effectively handled is by establishing a store budget to control both inventory and turn-over.

Budget Controls.

The subject of budget control is too extensive to discuss at this time, but it is very essential that revenue, expenses, capital expenditures, construction, cash, new business, and other activities be budgeted, in order to establish a definite and sound basis of operations. Executive control of these activities is impossible, unless some means is provided for comparing actual performance with the results that must be secured in order to insure a profitable operation of the entire enterprise. These conditions must be observed and analyzed monthly, in order that necessary action can be taken to properly balance the actual with the anticipated or expected results.

THE IMPORTANCE OF PROPER EQUIPMENT

The system may be properly designed, the procedure correctly out-

lined, the clerical personnel perfectly trained and supervised, but unless the same amount of care is used in the selection of the equipment, the results will not be satisfactory. It has been said that records must provide information when needed. I claim that this is not sufficient, because this involves too great a factor of the human element. Unless records reveal the necessary information and sound the necessary warnings, concerning every condition that demands attention, they are not accomplishing what may reasonably be expected of them. The use of visible equipment is the only positive way to insure efficient record control, because colored signals flash the true situation concerning every operating function. Laborious searching is eliminated, and information that might other wise be hidden and overlooked is revealed in order that the necessary action may be taken. The clerical operating cost is reduced at least fifty per cent. and the entire procedure is greatly simplified.

The relation of clerical labor cost to the cost of office forms, supplies and equipment is approximately thirty to one. That is, for every dollar spent for office equipment and supplies, $30.00 is spent for supervisory and clerical salaries. This fact emphasizes in no uncertain terms the extreme importance of designing and selecting the forms and equipment that will provide the greatest possible efficiency, the most positive control and effect the greatest reduction in clerical labor cost.

Jupiter Pluvius to the Rescue

It is not often that Nature lends its help towards collecting accounts in arrears, even when hard times is used as an excuse for postponing payment. Such assistance was, however, rendered recently at the collection office of one of the rural power districts. The following report by the Superintendent explains just what happened. No doubt there are others who would like to know how it was arranged.

"Enclosed find my cheque for $15.41, which Mrs. H—— paid at Public Utilities office Saturday afternoon.

"Mr. N— says that Mrs. H— stated that she will pay the balance weekly.

Yours truly,

(*Sgd.*) ——— "

"P.S.—Since writing this letter Mr. H— dropped in and paid $10.57 on the arrears. Lightning blew the fuse at his place and he thought, and for that matter still does, that he was cut off. I took the money and told him that we would turn the lights back on again."

New Rural Office in Sutton

WHEN the York radial line to the Village of Sutton was abandoned, this Commission purchased the old station building in the village together with a lot 100 by 200 ft. A new sub-station to supply the municipality and a portion of the Keswick R.P.D. was erected on the north end of the lot and the old station building altered and overhauled for use as a rural office and stores

This building was two storey, of frame construction, 40 by 35 ft. outside dimensions and supported on wooden posts.

The waiting room and ticket office have been converted into a main office, 14 by 27 ft., the walls and ceiling sheeted with fir and painted a light cream color, and the hardwood floor covered with battleship linoleum A section of the freight room, 11 by 14 ft., was lined with ten-test, suitably panelled and finished to correspond with the main office, for use as a private office for the superintendent.

The stores space is 39 by 19 ft. downstairs, while upstairs one large room is used for meter test rack and meter storage, one room for the foreman's office, one room for substation meters and two rooms for storage of small and more valuable material.

A cement basement 39 by 14 ft. was installed under the office section of the building, with tile drainage to a sump, and an automatic sump pump to keep the cellar dry.

An automatic pumping system having 320 gallons per hour capacity, was installed for the domestic water supply. Two wash rooms were provided on the second floor, and hose connections run into the garage and outside of the building. A septic

tank with 240 feet of tile distributing bed was installed.

The heating system is hot water, the offices, meter rooms and wash rooms only being heated at the present time. An oversize boiler, however, was installed to provide sufficient capacity for heating the remaining rooms upstairs and the garage, if required, in the future.

The building was entirely rewired, Westinghouse no-fuse load centre being used for both main entrance box and distributing panels instead of fuses.

On the outside, the building was originally covered with sheet metal two-thirds of the way up, the remainder clapboarded. The lower portion has been strapped, covered with metal lath and given three coats of stucco finished in a dark cream color; the wood-siding was painted to match the stucco and the trim, green.

A frame and stucco garage, 24 by 24 ft., finished to match the main building, was erected immediately adjoining the stores, provision being made for extending it for one additional truck if required.

The lot has been levelled, top dressed with from 2 to 3 inches of loam, and planted with grass seed. 280 evergreen trees have also been planted and flower beds laid out in accordance with a landscape design prepared by Mr. Frank Newman of the Provincial Government Reforestration Stations at St. Williams. Broken stone was spread on the driveway and the path between the main building and the sub-station.

Several letters have been received from residents and officials of the village complimenting the Commission on the appearance of the office and the improvement to this site, which is one of the principal corners in the village.

Load Building Possibilities with Electric Heating Devices

In the July BULLETIN the article under the above title refers on page 241 to a small capacity water heater (*Figure 5*) which is provided with a cord and plug so as not to require special wiring. The Approvals Laboratory under the provisions of the Canadian Electrical Code has refused to accept this type of connection for any permanently-connected water heater.

140-Ton Motor Operated Transformer Transfer Truck

By H. L. Wagner, Assistant Engineer, Electrical Engineering Dept., H.E.P.C. of Ont.

THE motor operated transformer transfer truck, described in this article, was installed by the Hydro-Electric Power Commission of Ontario, at their Chats Falls Transformer Station. As this method of transformer transfer, is a distinct departure from the ordinary procedure, especially in Canada, there may be some details, which will be of interest to the Engineering profession.

After complete inspection of the transformers, in the generating station, the truck is employed to convey the transformers from the generating station to the transformer pockets, which are located over a transformer tunnel adjacent to the downstream face of the dam. The average distance to be traversed from the generating station to the transformer pockets is 355 feet. In negotiating this distance the truck with transformer has to be turned through an angle of 52 deg., 39 min. Since it was not feasible for the truck to be run over a track with so sharp a degree of curvature, a turn-table was utilized.

The transfer truck travels on a track laid with 80 lb. rails, spaced 11 ft., 0 in., on centres, and these rails are extended into the generating station a sufficient distance to allow for inspection or dismantling of the transformers under the crane. See figures No. 1 and 2.

TRUCK

In order to secure flexibility in the truck and to assure, as far as possible, a uniform distribution of the load through each of the truck wheels, the truck was fabricated in two separate sections, which were then connected by coupling pins. Each section is supported on 4–24 inch diameter, cast steel, single flange wheels, with turned treads, and mounted on roller bearings.

The wheels are designed to carry the full maximum load with a safety factor of five.

The bearings are designed to take a maximum load of 54,500 lb. per wheel, when the truck is stationary and the transformer is being run off or on the truck, and to sustain a total moving superimposed load of 308,000 lb., including 10 per cent. for impact.

A pair of 80 lb. rail bridges are provided for spanning between the truck rails and the transformer pocket rails.

TRUCK TRAVEL

The truck is drawn along the transformer runway track by means of a reversible motor and cable drum, mounted on the truck, The cable is attached to a snubbing yoke anchored to the rails with two rail clamps.

TRANSFORMER TRAVEL

The transformer is moved from the truck to the transformer pocket, or the reverse, by means of the reversible motor and a second cable drum,

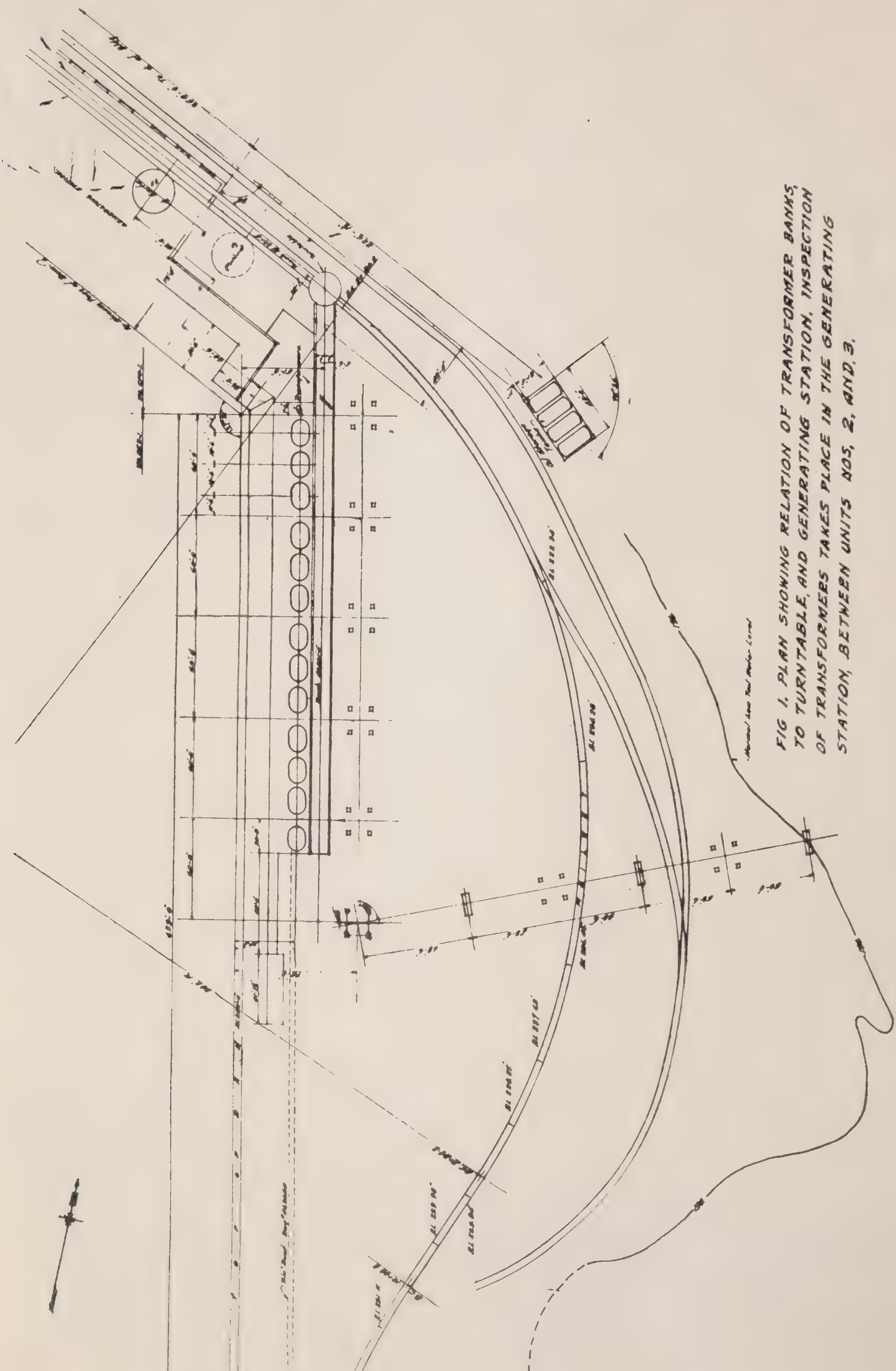


FIG. 1. PLAN SHOWING RELATION OF TRANSFORMER BANKS, TO TURNTABLE, AND GENERATING STATION. INSPECTION OF TRANSFORMERS TAKES PLACE IN THE GENERATING STATION, BETWEEN UNITS NOS. 2, AND 3.

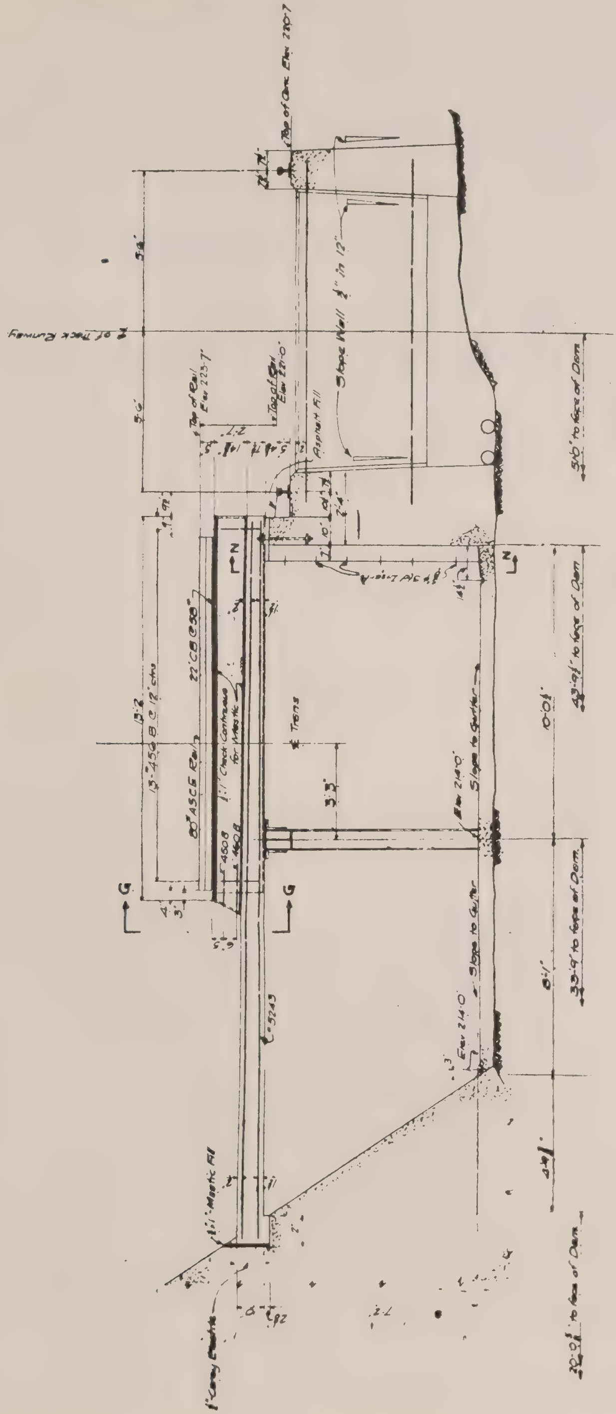


FIG. 2. TYPICAL CROSS SECTION OF TRANSFORMER TUNNEL ON CENTRE LINE OF TRANSFORMER POCKET

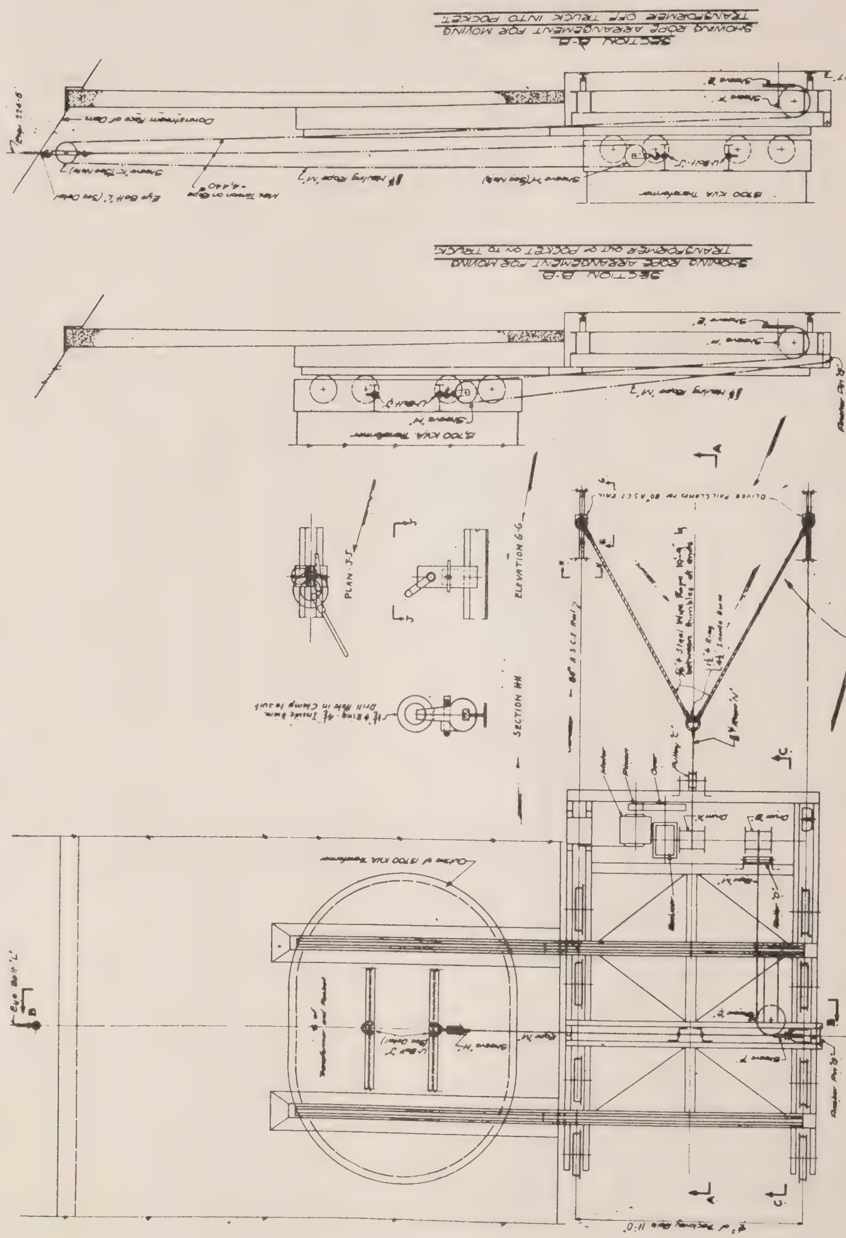


FIG 3. PLAN OF TRUCK AND ONE TRANSFORMER POCKET SHOWING ROPE ARRANGEMENT FOR MOVING TRANSFORMER OUT OF POCKET ON TO TRUCK.

mounted on the truck. The cable passes through a set of sheaves, two of which are attached to the truck. When the transformer is being transferred to its pocket two portable sheaves are employed in the cable. One is hooked to a "U" bolt on the transformer and one is hooked to an eye bolt anchored in the concrete dam at the rear of the pocket. When the

transformer is being removed from its pocket one portable sheave is employed in the cable and is hooked to a "U" bolt on the transformer, the dead end of the cable being anchored to a pin on the side of the truck farthest from the pocket. See figure No. 3.

Mechanical Features

The motor used is a 6 h.p. slip ring, reversing type for crane and hoist duty, 550 volt, 3 phase, 25 cycle capable of developing a normal running torque of 45 pd. ft., at a full load speed of 700 rev. per min., and a starting torque from standstill of twice the normal running torque, complete with reversing drum switch, with primary and secondary control and resistors designed for crane and hoist duty. The whole is of weatherproof construction for outdoor use.

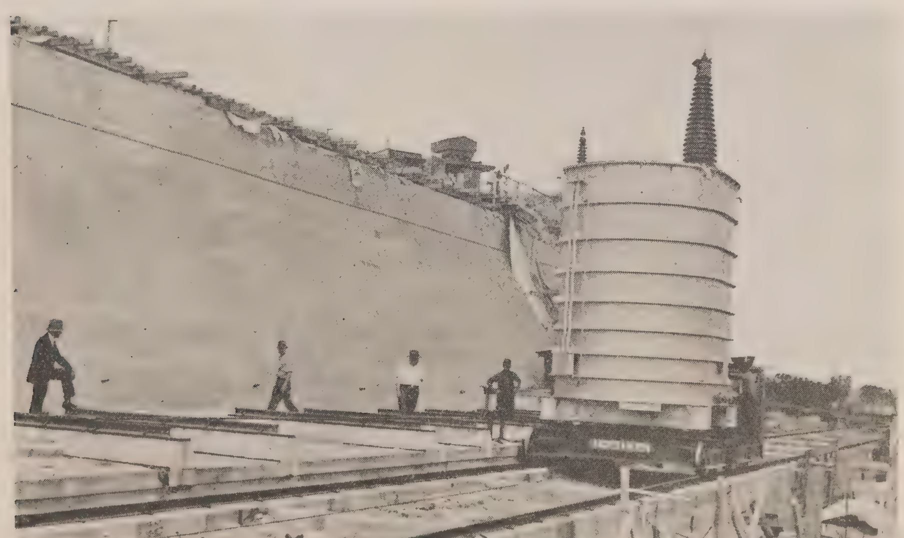
Transmission

The motor is connected to the shaft by means of gearing which is totally enclosed and weatherproof.

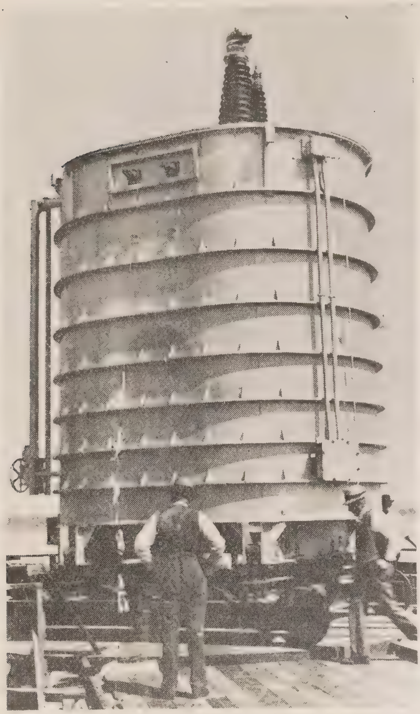
The transmission from the motor shaft to the secondary shaft is by means of a spur gearing and from the secondary shaft to the main shaft through worm gearing. The gearing ratio is arranged to provide a truck travel speed along the transformer runway track of 40 lineal feet per minute, while by means of the sheave arrangement the travel speed of the transformer to or from the transformer pocket is 20 lineal feet per minute.

Drums and Cable

The cable drums have a diameter of 10 inches and are each capable of carrying 100 lineal feet of 5/8 inch diameter wire rope. They are connected to the shaft through square



Transfer Truck with 15,700 kv-a. transformer drawing itself along transformer runway tracks by means of the truck mechanism.



jaw type clutches, which are protected by guards.

Alemite bayonet type fittings are provided for cable drums, sheaves, rollers, etc.

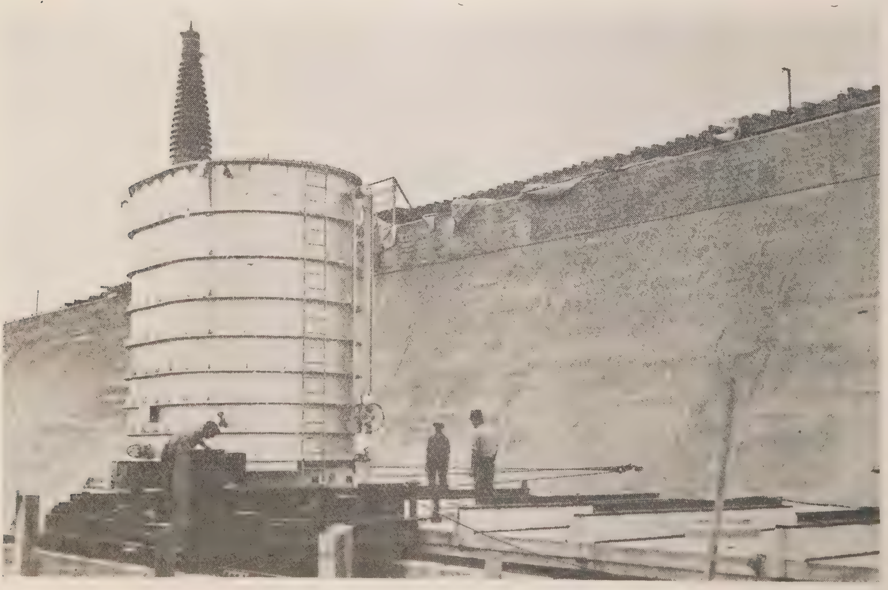
Wiring

A spring take-up power cable reel is provided, which is capable of carrying 70 lineal feet of type "S" heavy duty electric cable, composed of 4 No. 10 B & S conductors, one conductor of which is grounded to the metal frame of the truck.

Truck Brake and Anchor

A wheel operated rail brake shoe is provided in order to facilitate the operation of spotting the truck opposite the transformer pocket, and a rail clamp type of anchor, wheel

Left—15,700 kv-a. transformer on transfer truck being rotated on turntable.



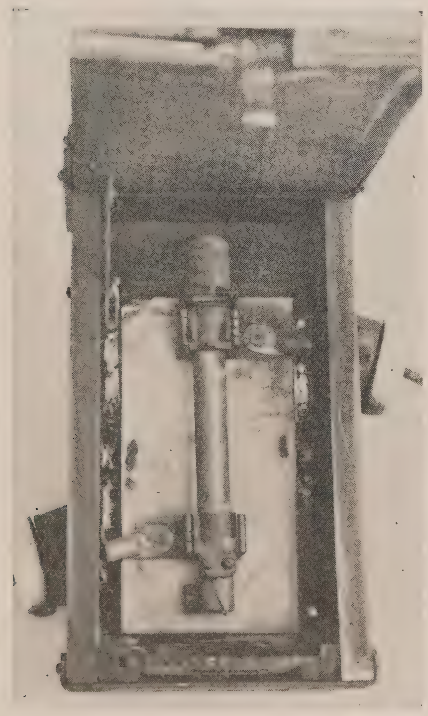
15,700 kv-a. transformer being pulled from the transfer truck to its pocket by means of the truck mechanism.

operated, is provided for anchoring the truck during the transfer of the transformer to or from its pocket.

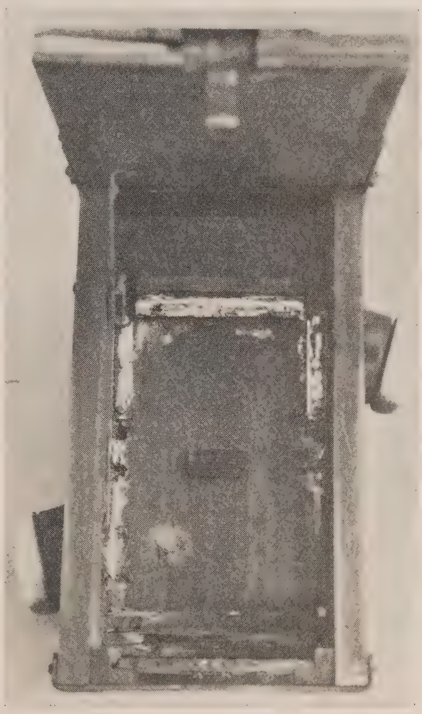
The truck has been in service during the placement of thirteen transformers and no difficulties have been encountered. The average time for three men to place a transformer on the transfer truck in the generating station and move it to, and place it in the transformer pocket is 70 minutes. This includes the time occupied in turning the truck on the turntable. Of this time 15 minutes is required to move the transformer from the truck into the pocket.

Wood Box Cutouts

On a 4,000–2,300 volt rural line protected by wood box type cutouts (see photographs) the fuse holder was removed to permit working on the line. Before proceeding to ground the line it was noticed that lamps beyond the cutout were still alight.



Wood Box Cutout with fuse in position.



Wood Box for Cutout with marble base removed showing charred path in wood between terminals.

The cutout was removed for inspection and a test in the laboratory showed a breakdown between various points on the marble base at 2,300 volts.

The accompanying photos show the fuse in position and also the box with the marble base removed. In the latter picture the charred path in the wood between terminals is clearly shown.

This incident emphasizes the necessity of grounding dead (?) lines before commencing work on them.

Association of Municipal Electrical Utilities

Minutes of Convention

The thirty-first Convention of the Association of Municipal Electrical Utilities was opened at Bigwin Inn, Muskoka, at 2.30 p.m., on Thursday, June 23rd, 1932, with the President, Mr. C. E. Schwenger in the chair.

In opening, the President welcomed the delegates to the Convention and referred to those not present, particularly Mr. Charles T. Rutland who had passed away suddenly a few days previously.

It was moved by Mr. J. W. Purcell and seconded by Mr. A. Demers THAT the Secretary be instructed to write a letter to the bereaved family of the late Charles T. Rutland expressing the sympathy of the Association. —(*Carried*).

Communications were read by the Secretary from the Canadian National Railways, inviting the Association to hold its Convention at Ottawa next year and also from the General Brock Hotel, Niagara Falls, asking the Association to Niagara Falls. These communications were laid over to be considered at a later time.

Reports of Committees

A report by Mr. W. R. Catton, Chairman Rates Committee, was read. It was moved by Mr. E. V. Buchanan and seconded by Mr. O. H. Scott THAT the report of the Rates Committee be adopted and forwarded to the Hydro-Electric Power Commission of Ontario.—(*Carried*).

Correspondence between Mr. J.W. Peart, Chairman Regulations and Standards Committee and the Electrical Inspection Department concerning plugs and receptacles for electric range connection was read.

It was moved by Mr. E. V. Buchanan and seconded by Mr. W. E. Reesor THAT the Electrical Inspection Department be asked to insist on the rule that calls for a receptacle and plug for the connection of electric ranges.

Amendment moved by Mr. O. H. Scott and seconded by Mr. A. W. J. Stewart, THAT the matter of the use of receptacles and plugs for electric range connection be deferred until we have further information.—*Carried*.

Mr. E. V. Buchanan presented a report from the Committee on Research and moved its adoption. On being duly seconded, Mr. Buchanan's motion was carried.

Mr. R. E. Jones, Assistant Engineer, Distribution Section, Electrical Engineering Department, Hydro-Electric Power Commission of Ontario, read a paper entitled "Development of Fuse Cutouts", which was illustrated with lantern slides. Discussion following Mr. Jones' paper was by Messrs. E. V.

Buchanan, E. R. Lawler, E. I. Sifton and C. E. Myers.

The session then adjourned and the meeting was turned over to the Ontario Municipal Electrical Association as a joint session when matters more particularly of interest to that Association were discussed.

At 12.30 p.m. on Friday, June 24, the Association met with the Ontario Municipal Electrical Association at a Convention luncheon with Mr. C. E. Schwenger, President Association of Municipal Electrical Utilities as Toastmaster. Mr. C. A. Maguire, President Ontario Municipal Electrical Association introduced the guest speaker, the Right Honourable Arthur Meighan, K.C., P.C., Commissioner, Hydro-Electric Power Commission of Ontario, who gave an address on "Democracy".

The second session of the Convention opened at 2.30 p.m., when Mr. G. A. Brace, Sales Manager, Ferranti Electric Limited, Toronto, presented a paper entitled "Surge Absorbers" which was illustrated by lantern slides and moving pictures. Discussion following Mr. Brace's paper was by Messrs. W. B. Buchanan, E. R. Lawler, A. B. Cooper, R. E. Jones, H. C. Barber and G. F. Drewry.

Mr. Henry J. Johnston, Remington Rand Incorporated, Buffalo, N.Y., gave a paper on "The Importance of Record Control to Executive Management", which was illustrated by moving pictures. Discussion following Mr. Johnston's paper was by Messrs. D. B. McColl, W. H. Childs, R. L. Dobbin, G. Appleton, W. M. Rogers and H. T. Macdonald.

The session then adjourned

At 6.30 p.m. the Association met with the Ontario Municipal Electrical Association for the Convention dinner when Mr. C. A. Maguire, President O.M.E.A. was Toastmaster. Mr. T. J. Hannigan, Secretary O.M.E.A. introduced Mr. M. A. Mahoney of Ottawa, who gave an illustrated address entitled "The Trail of '98", in which he told of his own experiences during the Yukon gold rush.

The third session of the Convention met at 10 a.m. on Saturday, June 25th, when Mr. J. S. Keenan, Assistant to the Manager, General Merchandising Department, Canadian General Electric Company, Limited, read a paper on "Load Building Possibilities with Electric Heating Devices" which was illustrated by lantern slides. Discussion following Mr. Keenan's paper was by Messrs. W. J. Wylie, J. F. Tomlinson, R. T. Jeffery, O. H. Scott, J. E. B. Phelps, W. F. Sutherland and W. E. Reesor.

Mr. M. B. Hastings, Vice-President Powerlite Devices, Limited, presented a paper entitled "The Photronic Photo-Electric Cell and Some Typical Applications".

The Convention then adjourned.

The register shows the total number of delegates who attended the Convention as 295, being classified as follows:—

Class "A"	62
Class "B"	123
Commercial	63
Associates	26
Visitors	21

The hotel reported the total number of persons included in the Convention party to be about 450.

THE BULLETIN

Published by

HYDRO-ELECTRIC POWER COMMISSION of Ontario

190 University Ave. Toronto

Subscription Price $2.00 Per Year

Why Exchange Charges Must Be Added to Interest Payments

(A Statement by the Hydro-Electric Power Commission of Ontario issued for publication on September 21, 1932).

WITH reference to the subject of exchange, which has been under some discussion in the public press, the Hydro-Electric Power Commission desires to say that it is not responsible for the prevailing state of international trade. The problem of exchange is, as it were, forced upon the Commission, as well as upon various municipal bodies, as a result of world economic condition. Obviously, therefore, it is important that representations to the general Hydro consumers should make it clear that the additional cost of Hydro service resulting from exchange is a cost which cannot be avoided. Exchange becomes a legitimate part of the actual cost of power, just as much as interest on capital invested is a part of the cost of power; in fact, the effect of exchange is, essentially, to increase the annual interest payable in Canadian funds.

In dealing with problems affecting the municipalities, the Commission never loses sight of the fact that it is the trustee for each and every Hydro municipality. In the application of general policies for the good of all, the Commission feels justified in counting not only upon co-operation between the various municipalities themselves, but also upon the co-operation of all the municipalities with the Commission, in order to secure results in the common interest; and thus in the matter of the present problem of exchange the Commission takes the position that there should be no approach to the problem which would involve discrimination as between individual municipalities.

When it is suggested that the Commission should draw upon certain of its reserves in order to take care of indebtedness incurred through charges for exchange upon United States funds, an important fact is disregarded, namely, that the funds which have been collected for these reserves were designed to take care of such matters as contingencies and

CONTENTS

Vol. XIX No. 9
September, 1932

obsolescence of the plant generally, and stabilization of generating costs, and should be held available for such purposes. These reserves have been collected from the various municipalities upon a different basis from that applicable to apportionment of exchange costs; so that the suggested method of caring for exchange out of the Commission's reserves would necessarily result in a discrimination against some municipalities and in favour of others.

The Commission's position in regard to the collection of exchange from the municipalities is fully explained in the annual letter of the Commission dealing with the financial operations of the municipalities.

The Commisson as trustee of the municipalities is obliged by law and by its agreements annually to adjust the cost of power to the municipalities, and one of the important items is interest on money invested in the construction of the power and other works. A large proportion of these funds is secured by the issue of bonds by the Province of Ontario which require the payment of interest and principal in United States funds, and, consequently, in view of the unfavourable exchange rate, the Commission has been obliged to pay larger sums for interest than usual. No reserves for this purpose have in the past been provided. The reserves that have been accumulated are for other purposes, such as contingencies and obsolescence of the plant generally and stabilization of generating costs, and these in the course of time will require to be largely drawn upon in order to protect the power costs to the municipalities.

After full consideration of the strong financial position of the municipalities, the Commission deemed it best, in the common interest, to deal with the exchange by making an additional charge, to be paid each month along with the interim bill, as an addition to the monthly payment for power cost, rather than making payment in a lump sum at the end of the year. In almost all instances, the local Commissions are financially in a position to pay such amounts, and especially so, since, as indicated by the Commission's investigation, such a course will not necessitate a revision of the local rates to the consumers of the municipalities.

It should be appreciated that, year by year, any surplus resulting from the operations of the Hydro Commission has been returned to the municipalities and thus the municipal Hydro systems have accumulated not only their own reserves corresponding to the reserves of the Commission, but also have accumulated additional operating surplus, and thus this total operating surplus represents not only

their local operating surplus, but also that resulting from the Commission's operations.

Thus in the case of the Hydro municipalities the financial position of the utilities is exceptionally sound. The total plant value of the municipal electrical utilities as of Dec. 31, 1931, amounts to $86,551,982.32, with total accumulated reserves and surpluses amounting to $53,235,314.49—or 61.5 per cent. of the total plant value. These reserves and surpluses are divided, $21,885,091.21 for sinking fund and debt retirement; $15,441,179.51 for renewals or depreciation, and a surplus amounting to $15,909,043.77. On the other hand, the total investment of the Commission for power properties—other than Northern systems—as of Oct. 31, 1931, is $260,418,445.65, with reserves to the amount of $58,779,946.55, which reserves are but 22.57 per cent. of the capital investment. These are apportioned $21,394,972.88 for sinking fund; $20,234,275.55 for depreciation or renewals, and $17,150,698.12 for contingencies and obsolescence of the plant generally and stabilization of generating costs.

In the case of the municipalities served from the Niagara System, the estimated total increase in interest charges, due to exchange, is $1,016,754, and is equivalent to an added interest charge of about six-tenths of 1 per cent. on the proportionate share of the capital on which interest is charged to the various municipalities during the year 1931.

The Ontario Hydro-Electric Power Commission has been fully aware of the situation which the heavy exchange rates have created for the Hydro municipalities and share with them the desire to maintain their present rates to consumers. In the efforts to accomplish this, however, the Commission does not regard it as advisable to attempt to maintain rates by utilizing, as some have suggested, its own reserves—which are set aside for a specific and required purpose—when at the present time most of the municipalities are quite able satisfactorily to take care of the exchange situation by drawing upon their local surpluses which, as pointed out, include the past surpluses of the Commission.

Vibration and Fatigue in Electrical Conductors

By A. E. Davison, J. A. Ingles and V. M. Martinoff, Transmission Section, Electrical Engineering Dept., H.E.P.C. of Ont.

(Presented at Summer Convention of the A.I.E.E. at Cleveland, Ohio. June 20-24, 1932.)

BECAUSE of a general increase in the unit working loads as well as in sizes of conductors, since about 1920, vibration has now become a problem for transmission organizations.

This very rapid vibration of overhead conductors (sometimes resulting in a musical note) was probably first reported, as deteriorating the mechanical characteristics of conductors, from California in 1923. These vibrations seldom have an amplitude exceeding two inches; the node lengths vary considerably and the frequency is of the order of 10 to 100 cycles per second.

Various organizations and interests, such as the State Electricity Commission of Victoria, Australia, the manufacturers of electrical conductors, and the electric utilities of Southern California, soon became interested in reports of these phenomena.

The need for fundamental preventives was made evident because of the following reports of results of vibration as found in the technical press. Bolts in towers became loosened and members were likely to become inoperative. Flat straps supporting arms of the towers seemed to vibrate on their own account. Insulator hardware has been damaged. In other cases, cables have had numerous strands cracked.

Remedial Measures

To overcome all these difficulties numerous mechanisms and appliances have been suggested and some of them function very well indeed. They are, however, always subject to the criticism that they may ultimately account for more harm than good. On the other hand, if the cause of the problem can be determined, and preventives applied at the source, there will then be little danger of the trouble showing up later at some unexpected point.

Bibliography of Vibration

A bibliography of the subject referring largely to cables and wires, and consisting of some 350 items, has been assembled, a large part of which was supplied by cable manufacturers, the American Society of Mechanical Engineers, and the Engineering Foundation. Of these, 65 articles were reviewed and studied. These articles may be divided into two sections. (1) those which deal with reinforcements, absorbers, and generally with curative measures; and (2) those which approach the problem from a fundamental standpoint, by determining the cause and proposing and reporting upon preventive measures.

Review of Investigational Work Done on Vibration in Cables

The more important researches

were carried out by Relf and Ower, Karman, Shiba, Varney, Stockbridge, Thoma and Bate. Articles by Relf and Ower[1] and by Karman,[2] dealt with the theory of formation of eddies at the lee-side of stream flow and their relations to the periodicity of the resulting vibrations. Shiba of Japan has photographed the eddy formations, using smoke streams and a special camera taking 12,000 to 20,000 pictures per second by which the relation of eddy frequency to that of the vibrations might be more readily studied. Varney,[3] Stockbridge[4] and Bate[5] discussed various dampers, and generally put forward curative measures and absorbing devices.

Effects of Conductor Shapes

Following reports of a field observation from the Pacific Coast that a three-strand cable did not vibrate as heavily as a standard cable,[6] also that a single strand wrapped about a cable seemed to reduce the vibration,[7] it was thought, although a somewhat impractical cable cross-section might result, that some important principle might be involved which had not been investigated sufficiently. Again, there appeared to be an opportunity of providing fundamentally a preventive of vibration failure by modifying the section of the conductor rather than that afforded remedially by adding reinforcements and absorbers. Accordingly it was decided to make further studies of specially stranded and deformed cables.

Attention was soon called to Thoma's[8] findings, namely, that the section of the cable did play an important part in the vibration characteristics. It was thought that by upsetting the symmetry of the section, the eddies would be disrupted. This is explained in the following theory.

Ideas Governing the Design of Non-Symmetrical Sections

The successive cross-sections of a 5/8 in. diameter round rod with a 1/8 in. diameter wire spiralled about it, as shown in Fig. 1, have been selected to indicate the complicated system of frequencies brought about by the eddy formation at each of these successive cross-sections along the cable. Balancing of eddy forces is demonstrated at individual pairs of cross-sections. A 5/8-in. plain round rod is examined for comparison and it will be seen that there is no balancing action in this case. Examination of stream line flow was carried out by referring to photographs of somewhat similar cases as obtained by Shiba.

Four variables which modify the resultant eddy action behind the rod and wire are introduced in each individual cross-section, namely:

(a) Frequency
(b) Phase
(c) Amplitude
(d) Neutral vibration plane

Each of these is studied in detail, as follows:

(a) Frequencies were calculated from the Relf and Ower formula. Assuming constant velocity of flow, the frequency is proportional to the diameter of the section. By varying this diameter, different frequencies will occur. In this case, variation is brought about by the spiralling of the wire about the rod. The effective diameter of the combination will be the diameter of the rod plus in cases

[1]For References see Bibliography.

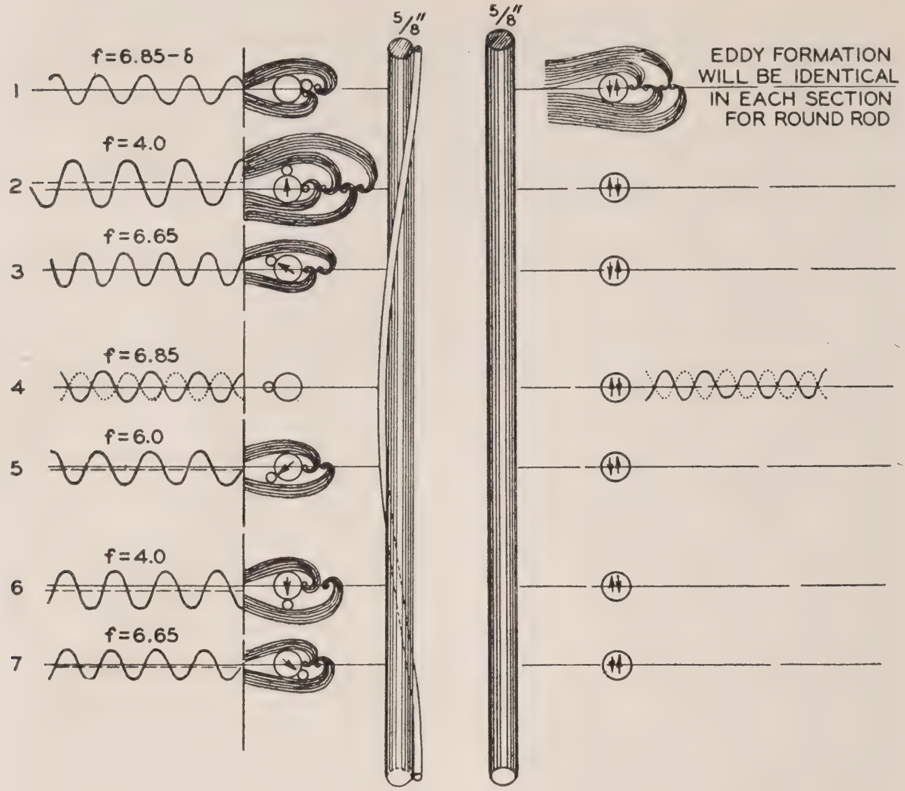


Fig. 1.—Study of Eddy Formation in Lee of Uniform and Non-Uniform Specimens.

Comparison of normal 5/8-in round rod and 5/8-in rod with 1/8-in wire spiralled about it.

$$\text{Frequency} = \frac{V}{D} \times \phi \left(\frac{VD}{e} \right)$$

Relf and Ower. Aeronautical Research Committee No. 825.

such as sections 1, 2, 3, 5, 6, etc., Fig. 1, a percentage of the diameter of the wire. Only the diameters were considered in determining the frequencies and the theoretical curveswere plotted from these values. These curves will then represent, to some scale, the actual frequency of the section.

(b) The phase of the vibration of an individual section will be governed by the position of the outer wire and has been plotted accordingly in the diagram.

(c) The force acting in the direction of vibration will be:

$$p = KV^2 \times D \text{ per ft. run per lb.}$$ [5]

Where P = force, V = velocity, D = diameter

Assuming velocity constant, the force will be proportional to the diameter The amplitude of the vibration will, therefore, be proportional to the

diameter. For each section in the diagram, the maximum amplitude has been plotted equal to the effective diameter and will, therefore, represent to scale the true amplitude.

(d) Vibration will take place about the centre of impact of the section which will be offset from the horizontal diameter of the rod. This has been indicated by a broken line in the diagram.

The eddy formation and resulting forces have been plotted for an instantaneous position of the rod and will reverse at periods according to the frequencies involved, as indicated by the double arrows in the case of the round rod and double wave at cross-section No. 4, Fig. 1. No attempt has been made here to establish the exact mathematical value of the quantities involved. This is being investigated. The diagram illustrates the principle qualitatively, but not quantitatively.

It will be seen that at sections 3 and 7, and at 2 and 6, Fig. 1, the frequencies and amplitudes (therefore forces) are equal but are 180 deg. out of phase. They will, therefore, tend to balance one another in the direction of vibration, thus reducing this objectionable feature. In the case of the symmetrical round rod, the eddy formation will be identical at each section and no balancing tendency is evident.

At section 4, fig. 1, of the combination of rod and wire, an unstable condition is introduced due to the fact that the forces on the sections on either side of it tends to move the conductor in opposite vertical directions.

It must be noted that this discussion deals with a very small length of cable—with 8 in. lay of the wire; the two boundary sections are separated 8 inches. Similarly, with three-strand cable the boundary sections would be separated by only two and two-third inches. In practise it is highly probable that over such a short section when compared with the length of the span, wind velocity would be approximately constant.

Special Sections Available for Study

The single wire spiralled about the rod is impracticable, on the application of tension, as the load on the cable becomes eccentric. This analysis, however, points the way to modifying, in a practical way, the fundamentals of vibration in cables. For instance, in a three-strand cable, this same complication of frequencies would be introduced, but the tension would be uniformly balanced over the cable section. The four-strand cable is also a good example and is in common use, more especially in steel wire rope. Almost any sector or acorn shape may be made without much loss of mechanical strength by rolling or hammering the round cable as in insulated three-phase cables.

As a basis on which to work, it was decided to make sample specimens of sections of cables which were statically balanced so that they would not pull eccentrically. The section should, however, be unsymmetrical about the horizontal axis of the cable and at the same time be unsymmetrical for successive sections along the cable; or in other words, simulate those characteristics which seemed to interefere with vibration in the cable with extra wrapping re-

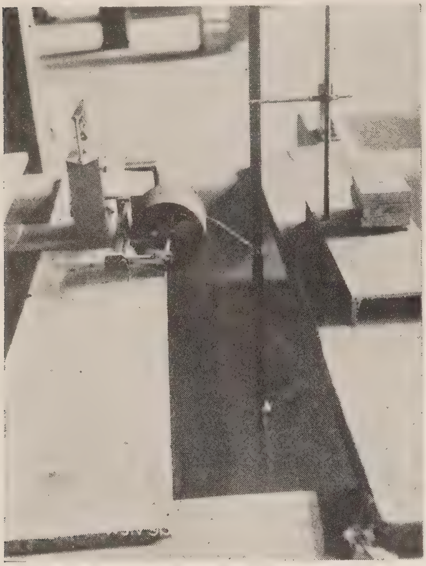


Fig. 2.—Sideview of Apparatus Used in Recording Vibrations of Experimental Specimens in Water.

ferred to above. It was evident that as uniform an eddy action could not be expected over a length of these special cables, as appears to be the case with standard cables or round rod, with a consequent reduction of the power input from the wind.

Laboratory Work

Experimental work, based on these assumptions, was carried out in the Hydraulic Laboratory of the University of Toronto. Dr. Thoma's experiments and methods were followed quite closely. Water was used as a medium. The effect of change of shape on the amplitude of the vibration was sought. The specimen conductors of various peculiar shapes were tried at 5 different velocities of water. The range of velocities was from 4 to 7 inches per second. The sample was fastened to a flat steel strap one inch by one thirty-second inch and 5 ft. long, Fig. 2. This strap was used in preference to the elastic rod which Thoma used as it restricted movement in the direction of the flow of water most effectively. A light pointer was attached to the strap. This pointer traced the wave motion on a smoke chart, placed on the drum of a vibrograph.

The samples were divided into five groups. Each group had a circular sample as a standard and a number of irregular cross-section samples was compared with it. Projected dimensions, or effective diameters, of all the samples within each group were approximately the same, the object being to obtain the same frequencies of vibrations. In order that the vibrating system in each group should be as nearly as possible the same, the samples were made equal in weight and with centres of mass at the same point as that of the standard.

The adjustment for resonance was brought about by varying the length of the strap between the sample and the clamp till the maximum amplitude of vibration of the strap was obtained. Other sections in the corresponding group were similarly treated.

That the required similarity was obtained was evidenced by the fact that in each group adjustment for fundamental resonance of the various samples was negligible and was seldom necessary at all so that the natural frequencies of the systems were approximately identical.

Owing to variations in speed of the smoke chart, no exact check could be kept on the observed frequencies, but the fact that no important adjust-

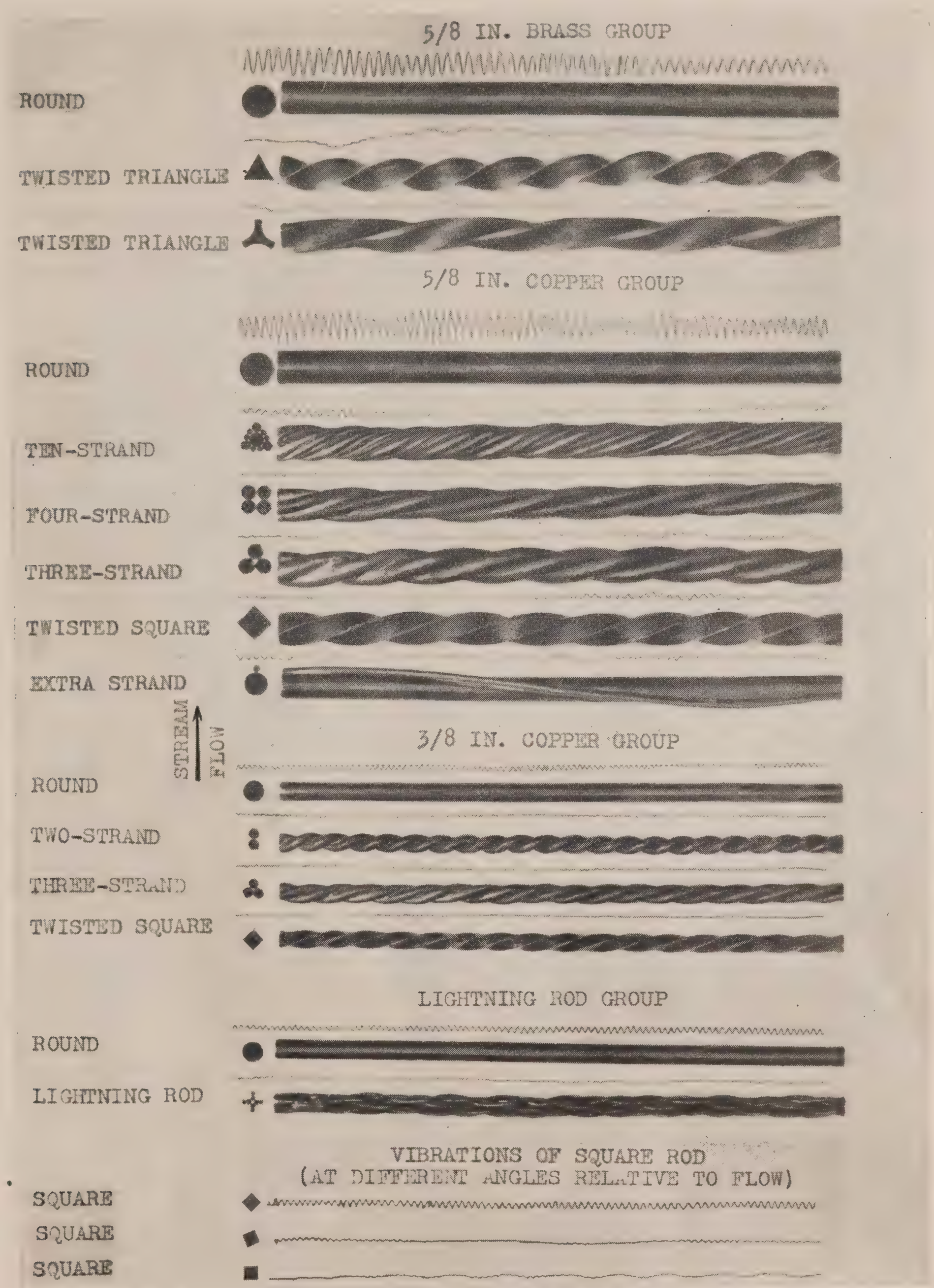
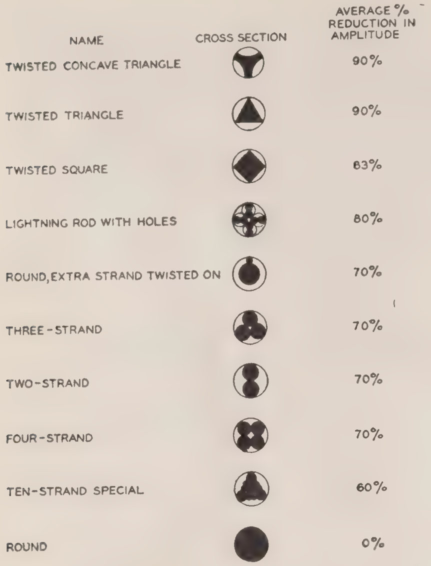


Fig. 3.—Vibrations in Water Recorded Comparatively for Various Sections and Types of Conductor.



NAME	CROSS SECTION	AVERAGE % REDUCTION IN AMPLITUDE
TWISTED CONCAVE TRIANGLE		90%
TWISTED TRIANGLE		90%
TWISTED SQUARE		83%
LIGHTNING ROD WITH HOLES		80%
ROUND, EXTRA STRAND TWISTED ON		70%
THREE-STRAND		70%
TWO-STRAND		70%
FOUR-STRAND		70%
TEN-STRAND SPECIAL		60%
ROUND		0%

Fig. 4.—Tabulation of Percentage Reductions of Vibrations as Observed in Water.

List of shapes which reduce vibrations. Order of sequence: shapes giving maximum reduction lead the list.

ments were required within the groups leads to the inference that approximately identical frequencies were obtained in each case. In any case, the final purpose of the experiments was to derive qualitative rather than quantitative results. The design of specimens giving the same vibrating systems within each group (*i.e.*, the mechanical impedance) permitted the use of amplitude as a measure of the relative damping.

Conclusion Drawn from Hydraulic Experiments

Qualitatively the following conclusions may be drawn pending more practical experiments using air as a medium:

1. As evidenced by the charts, Fig. 3, it will be seen that so far as hydraulic experiments are concerned, the twisted triangular section overcomes most satisfactorily the tendency to vibrate.

2. It can be also noticed that practically all the sections tried, decreased the amplitude by at least 50 per cent. when compared with the round rod, Fig. 4. From the results, it would seem advisable to construct a cable approximating in cross-section a triangle. Fig. 5 shows a series of cable sections derived from the basic sections which in the laboratory evidenced a considerable reduction in tendency to vibrate.

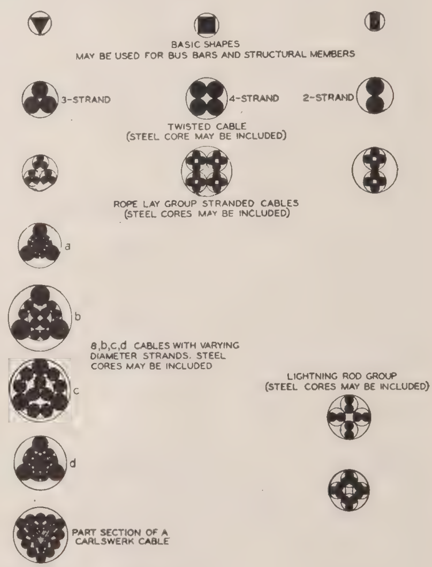


Fig. 5.—Desirable Cross-Sections for Cables and Buses Which are Exposed to Light Winds

Any combination of stranding, or grouping of strands of various diameters, which will approximate the basic shapes, *i.e.*, triangular, square, or rectangular, can be included in this set of cross-sections.

3. Even if these special triangular and rectangular sections prove impractical in cables, they may be used in outdoor buses where some difficulties of this nature may arise in future.

Later Steps in the Investigation of Vibration in Cables

1. At present special cables approximating triangular cross-sections have been made and are being strung in air to see how closely the hydraulic experiments are in agreement with the practical case. Three sections have been suggested; first, the ordinary three-strand cable which was casually observed in the West as being comparatively free from vibration; second, a nine-strand cable which is made up of 3 strands of three-strand cable with rope lay; and third, a special nine-strand cable using two sizes of strands, the three larger strands so placed in the outside layer as to give approximately the desirable triangular effect, Fig. 6.

Any combination of stranding, or grouping of strands of various diameters, which will approximate the basic shapes, *i.e.*, triangular, square, or rectangular, can be included in this set of cross-sections.

The special rope lay cable introduces a feature which may be of great importance. Due to a characteristic of the stranding, air gaps, which will not collapse under tension, have been introduced. The presence of these air-gaps may serve to further upset the sequence of eddies behind the cable.

2. Acting conjointly with so-called "stiction" and "interstrand" friction, the elastic properties of the individual strands of a standard cable will tend

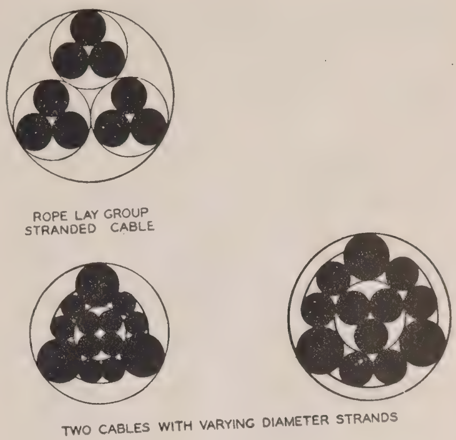


Fig. 6.—Most Practical Cross-Sections for Suppression of Vibration.

to modify the vibration. Investigation should be made with the object of segregating these and to determine the comparative importance of the damping in each case. Does interstrand friction absorb any energy at all at the comparatively long radii of curvature found in vibration phenomena?

3. Experiments should be carried out to verify the following predictions which were made on two cables (6 by 0.2108; 7 by 0.0705, 266,800 cir. mils A.C.S.R., Owl, and 30 by 0.1059; 7 by 0.1059, 336,400 cir. mils A.C.S.R. Oriole). An attempt was made mathematically to predict the characteristic dimensions of vibration in these two cables and to balance energy input against energy dissipated, the remainder of the energy doing work on the cable at points of discontinuity, such as clamps. Many assumptions had to be made. Initial attempts at measurement in the field were unsatisfactory and this work was temporarily abandoned.

4. A determination of the actuating

force per foot length of cable should be carried out. This sould be done in a suitable wind-tunnel with adjustable elastic supports for the specimen under test.

PRACTICAL DIFFICULTIES

There are many objections to any departures from standard cables such as are indicated by these experiments. It is hoped that so far as vibration is concerned the proposed sections will indicate some new properties which in some cases at least will outweigh practical difficulties, such as standardization.

The corona loss may be increased to some extent. Also the increased diameters would account for greater wind pressures and sleet loadings. There would be some difficulty in making joints. Two sizes of strands in one cable would be a digression from the standards. If more than one pass through the stranding machine is required on account of these various sizes of strand, then the result would be increased cost.

Discussions and studies of these details are deferred until there is an opportunity to confirm in a practical way in air that the amplitudes of vibrations are suppressed.

ACKNOWLEDGMENTS

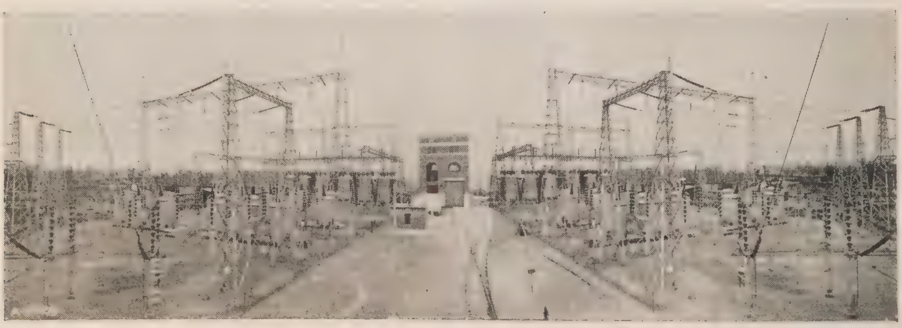
Thanks are extended to Messrs. W. P. Dobson and W. B. Buchanan of the Laboratories of the Hydro-Electric Power Commission for co-operation in this work and for making several valuable suggestions.

BIBLIOGRAPHY

1. "The Singing of Circular and Stream-Line Wires," E. F. Relf and E. Ower, Aeronautical Research Committee, No. 285.
2. "Flussigheits und Luftwiderstand," Karman and Ruback, *Physic Zeitschrift*, Vol. 13, 1912, p. 49.
3. "The Vibration of Transmission Line Conductors," T. Varney, *Aluminum, Limited*, Pamphlet, December, 1930.
4. "Overcoming Vibration in Transmission Cable," G. H. Stockbridge, *Elec. Wld.*, December 26, 1925.
5. "The Vibration of Transmission Line Conductors," E. Bate, *Jl. I. E. Australia*, Vol. XI, August, 1930, p. 277.
6. Pacific Coast Electrical Association Report "Conductor Vibration," *Elec. West*, May 15, 1930.
7. G. H. Stockbridge, *Elec. Wld.*, Vol. 86, No. 26.
8. "Hydraulic Damping of Cable Vibrations," Dr. H. Thoma, *Karlsruhe Electrotechnische Zeitschrift*, No. 22, 1931.

Four appendices, including bibliography, have been assembled during experimental work and the preparation of this paper. They are available upon requests to the authors. They are,

A. Visualizing vibrations in small wires.
B. Bibliography.
C. Treatment of resonance by electrical analogies verifying laboratory method of investigation.
D. Mathematical investigation of vibration of 5/0 and 6/0 cables. (6 by 0.2108: 7 by 0.0705, 266,800 cir. mils A.C.S.R., Owl and 30 by 0.1059; 7 by 0.1059, 336,400 cir. mils A.C.S.R., Oriole).



Use of Power by Hydro Domestic and Commercial Consumers up to the End of 1931

By G. J. Mickler, B.A.Sc., Sales Dept., H.E.P.C. of Ont.

ONE of the oustanding conditions which prevail during this so-called depression is that of the continued growth in the use of electrical energy by domestic and commercial consumers connected to the Hydro System throughout the Province of Ontario.

That Hydro service is one of the absolute necessities of life is borne out by facts covered in the 24th Annual Report of the Hydro-Electric Power Commission. In Statement D., commencing on page 386 of this report, are tabulated the vital statistics of every utility operating under the Hydro contract. These vital statistics consist of the number of consumers, the consumption in kilowatt-hours, the revenue collected, the average monthly consumption, the average monthly bill and the average net cost per kilowatt-hour for domestic and commercial service. The statement is divided up into three sections, the first section dealing with cities of over 10,000 population, the second section of towns between 2,000 and 10,000 population and the third section of villages below 2,000. The statistics are for the year 1931 only.

Standing by themselves as they do they do not convey as vivid a picture of existing conditions as they might if set side by side with statistics of previous years and as if they were totalled and represented graphically from the beginning of Hydro operation.

For a number of years the statistics contained in these tables have been presented so as to show the growth which has taken place in these two branches of service since the inception of Hydro and in order that present day conditions can be seen at a glance the figures of the 1931 Annual Report have been woven into the picture painted in previous years.

The statistics referred to above have been grouped together and summarized to develop averages under the various general groups mentioned above and the following tables show not only the results for the year 1931 but show the last three years in comparison with one another and the figures back to 1914 in three year steps. As the figures presented tell their own story it is not necessary to go into a lengthy explanation of their meaning. Suffice it to say that the general results show that the cost of power to domestic and commercial users in the Province among Hydro consumers is still on the decrease and the rate of consumption is steadily increasing.

Referring to the tables it will be found that Table No. 1 presents data on Domestic service for cities of 10,000 population and over. The figures presented show a substantial increase in the total annual revenue, also in the total number of kilowatt-

TABLE No. I.

Data for Cities over 10,000 Population.

DOMESTIC SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-Hours Consumed	Number of Con-sumers	Average Cost Per Kw-hr.	Average Monthly Bill	Average Monthly Consump-tion Kw-hr.
1914	12	614,925.00	12,646,400	55,597	4.86c	$1.06	21.8
1917	19	1,063,264.00	36,693,100	107,248	2.89	0.88	30.5
1920	21	1,926,924.00	84,328,000	154,186	2.29	1.11	48.4
1923	21	3,772,416.00	206,266,200	223,028	1.83	1.53	83.5
1926	21	5,374,069.00	324,290,285	255,109	1.66	1.80	108.0
1929	26	7,530,748.75	497,102,897	309,645	1.51	2.08	137.2
1930	26	7,921,316.00	541,876,998	315,611	1.46	2.11	144.4
1931	26	8,209,397.40	567,940,095	322,613	1.45	2.14	148.3

TABLE No. II.

Data for Towns over 2,000 Population

DOMESTIC SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-Hours Consumed	Number of Con-sumers	Average Cost Per Kw-hr.	Average Monthly Bill	Average Monthly Consump-tion Kw-hr.
1914	19	90,333.00	1,414,500	7,410	6.38c	$1.11	17.4
1917	27	180,375.00	3,824,600	15,731	4.71	1.01	21.4
1920	36	353,915.00	10,053,100	24,041	3.50	1.26	36.0
1923	43	651,499.00	25,411,300	34,135	2.56	1.57	60.1
1926	48	1,037,016.00	50,487,035	47,873	2.05	1.84	89.6
1929	54	1,474,547.24	68,283,456	57,699	2.16	2.11	97.8
1930	53	1,468,194.00	73,234,125	58,490	2.01	2.10	105.0
1931	58	1,541,490.08	78,359,573	61,583	1.97	2.13	108.1

TABLE No. III.

Data for Villages under 2,000 Population.

DOMESTIC SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-Hours Consumed	Number of Con-sumers	Average Cost Per Kw-hr.	Average Monthly Bill	Average Monthly Consump-tion Kw-hr.
1914	18	24,913.00	291,000	1,859	8.55c	$1.10	13.1
1917	77	97,516.00	1,412,500	8,334	6.90	0.96	14.0
1920	109	233,819.00	3,829,900	15,665	6.00	1.29	21.2
1923	142	531,505.00	11,429,100	29,689	4.72	1.59	33.7
1926	174	942,309.00	29,945,632	46,900	3.15	1.71	54.4
1929	193	1,251,564.03	46,755,369	57,075	2.68	1.80	67.2
1930	194	1,363,210.00	55,917,187	59,159	2.43	1.95	80.1
1931	205	1,475,204.49	58,484,789	63,270	2.52	1.98	78.4

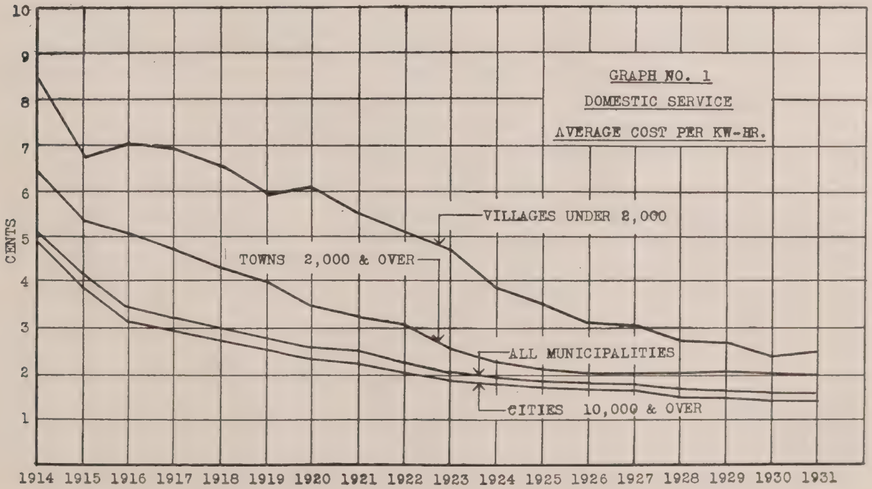
TABLE No. IV.
ALL MUNICIPALITIES TOTALLED.
DOMESTIC SERVICE

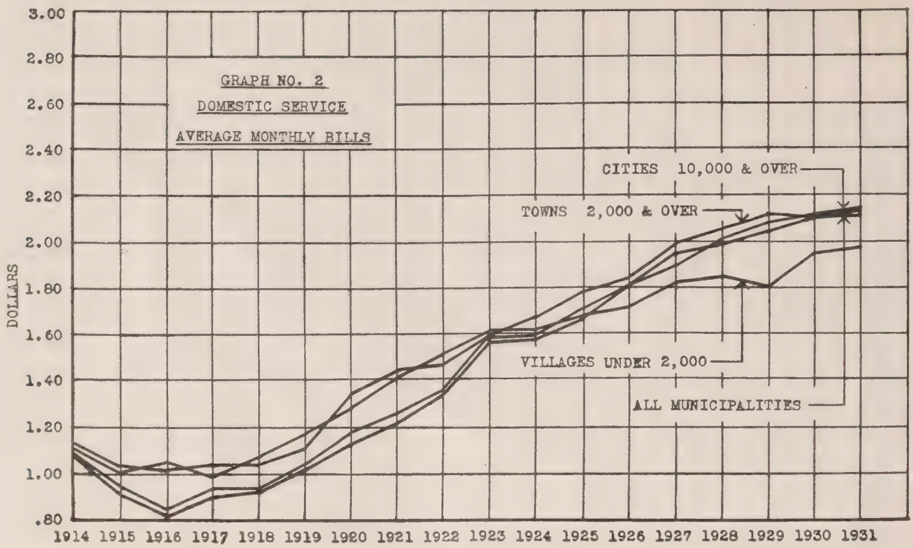
Year	No. of Munici-palities	Annual Revenue	Kilowatt-Hours Consumed	Number of Con-sumers	Average Cost Per Kw-hr.	Average Monthly Bill	Average Monthly Consump-tion Kw-hr.
1914	49	730,168.00	14,359,100	64,866	5.08c	$1.06	21.0
1917	123	1,340,855.00	41,930,200	131,313	3.20	0.91	28.6
1920	166	2,514,658.00	98,211,000	193,892	2.56	1.15	44.6
1923	206	4,955,420.00	242,926,600	286,852	2.04	1.54	75.7
1926	243	7,353,394.00	404,722,959	349,882	1.81	1.79	98.4
1929	273	10,256,860.02	612,141,722	424,419	1.67	2.05	122.5
1930	273	10,752,720.00	671,028,310	433,260	1.61	2.09	130.1
1931	289	11,226,091.97	704,784,457	447,466	1.59	2.12	133.0

hours consumed during the past year as well as an increase in the number of consumers, a slight increase in the average monthly bill and a slight increase in the average monthly consumption with a corresponding decrease in the average cost per kilowatt-hour to domestic consumers.

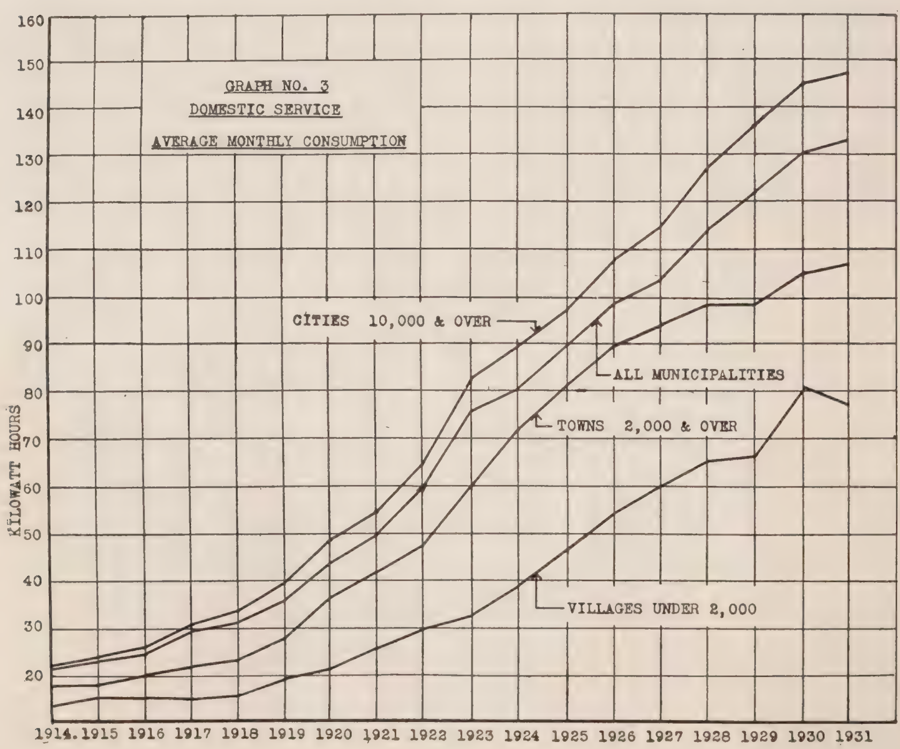
Table No. 2 presents data on domestic service also for towns between 2,000 and 10,000 population. Here again there has been a substantial increase in revenue and kilowatt-hours consumed. There has also been an increase in the number of consumers, in the average monthly bill and in the average monthly consumption while the average cost per kilowatt-hour has been reduced.

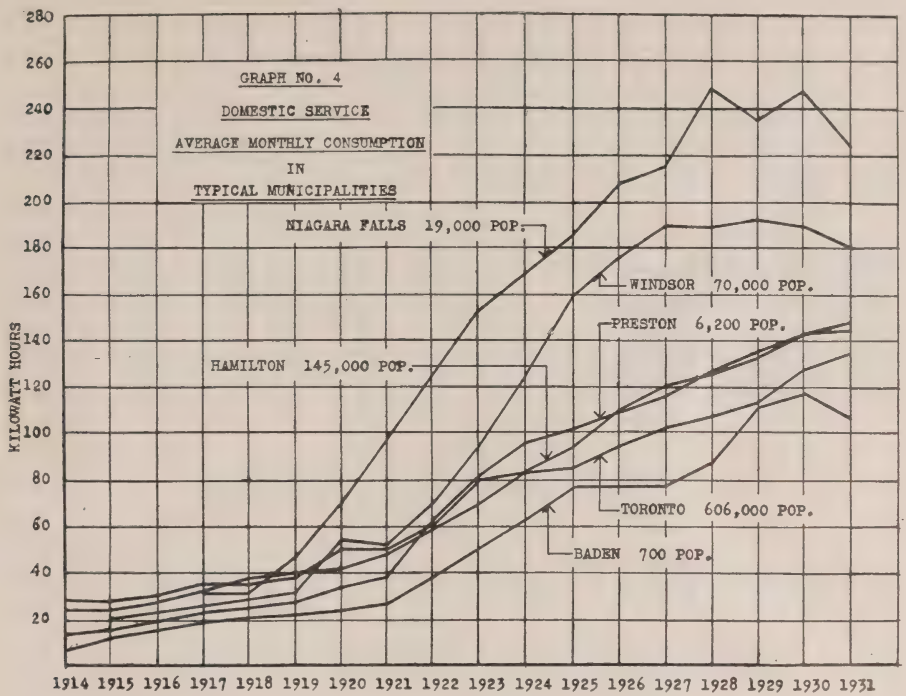
In Table No. 3 which refers to data for villages under 2,000 population, there has been an increase in the revenue and in the kilowatt-hours consumed, also in the number of consumers, but the average monthly bill and the average monthly consumption have been slightly reduced while the average cost per kilowatt-hour has increased somewhat. This may be due to the fact that in the average





small town there is a lack of large current consuming appliances which are more or less a necessity of life in the larger communities and when depressions occur the curtailment of the use of electricity in the smaller





towns has a more marked effect on average consumption, which is small at best, than it does in the larger municipalities. Consumers in the small towns can apparently go without lights whereas in the larger communities they must use a range and a water heater and consume a fair amount of current regardless of economy conditions.

In Table No. 4 the three previously mentioned tables are summarized and it shows that in all the municipalities taken as a whole the revenue for the past year has increased, kilowatt-hours consumed have increased

TABLE No. V.

DATA FOR CITIES OVER 10,000 POPULATION.

COMMERCIAL LIGHTING SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-Hours Consumed	Number of Con-sumers	Average Cost Per Kw-hr.	Average Monthly Bill	Average Monthly Consump-tion Kw-hr.
1914	12	536,350.00	14,048,500	12,439	3.80c	$3.94	103.7
1917	19	642,989.00	27,479,800	19,573	2.34	2.96	126.6
1920	21	1,103,599.00	50,358,000	25,505	2.19	3.77	172.0
1923	21	2,043,197.00	91,146,500	32,016	2.25	5.56	246.9
1926	21	3,393,186.00	147,581,714	40,675	2.30	7.08	308.0
1929	26	4,772,209.30	230,263,364	48,713	2.07	8.49	401.5
1930	26	4,919,496.00	242,278,308	50,046	2.03	8.31	409.6
1931	26	5,137,591.45	256,281,236	52,203	2.00	8.37	417.7

TABLE No. VI.

DATA FOR TOWNS OVER 2,000 POPULATION.

COMMERCIAL SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-Hours Consumed	Number of Con-sumers	Average Cost Per Kw-hr.	Average Monthly Bill	Average Monthly Consump-tion Kw-hr.
1914	17	71,457.00	1,362,000	2,393	5.25c	$2.61	49.8
1917	27	134,730.00	3,100,600	4,107	4.35	2.76	63.5
1920	36	221,867.00	6,179,400	5,736	3.59	3.30	91.8
1923	43	315,530.00	9,598,000	7,086	3.29	3.76	114.3
1926	48	430,467.00	15,709,616	8,310	2.74	4.31	160.0
1929	54	632,010.30	26,240,436	10,214	2.41	5.13	213.1
1930	54	661,857.00	27,841,568	10,274	2.38	5.38	226.4
1931	58	698,127.87	29,950,671	10.979	2.33	5.43	232.3

TABLE No. VII.

DATA FOR VILLAGES UNDER 2,000 POPULATION

COMMERCIAL LIGHTING SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-Hours Consumed	Number of Con-sumers	Average Cost Per Kw-hr.	Average Monthly Bill	Average Monthly Consump-tion Kw-hr.
1914	14	$ 16,974.00	259,200	825	6.55c	$1.74	26.6
1917	77	82,756.00	1,403,100	3,773	5.86	1.87	31.7
1920	109	152,497.00	2,799,500	5,255	5.89	2.45	45.0
1923	142	254,530.00	4,738,100	7,281	4.80	2.96	55.1
1926	173	352,942.00	8,505,684	9,459	4.15	3.22	77.7
1929	193	488,997.65	15,839,530	11,179	3.08	3.70	119.9
1930	193	513,518.00	17,718,146	11,553	2.89	3.76	129.9
1931	205	541,801.47	18,889,733	12,104	2.86	3.76	131.0

TABLE No. VIII.

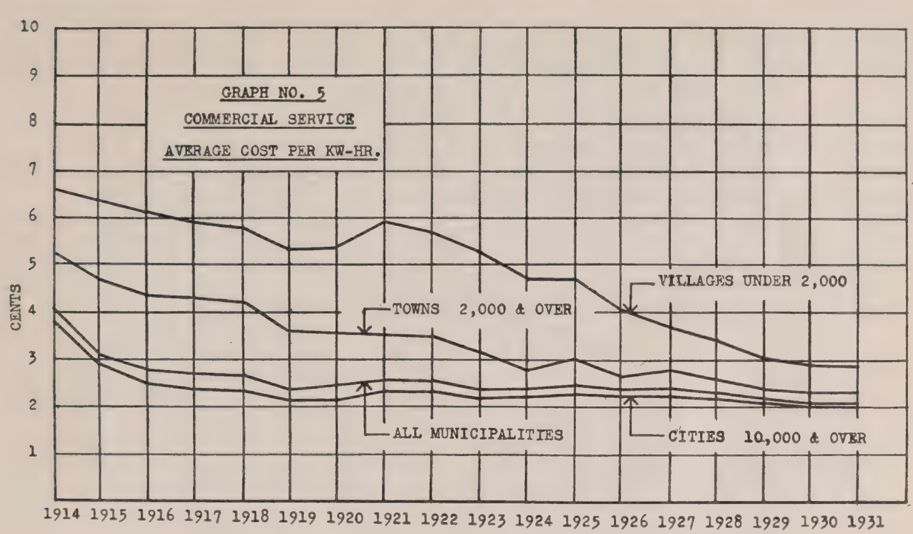
ALL MUNICIPALITIES TOTALLED

COMMERCIAL LIGHTING SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-Hours Consumed	Number of Con-sumers	Average Cost Per Kw-hr.	Average Monthly Bill	Average Monthly Consump-tion Kw-hr.
1914	43	$ 624,781.00	15,669,700	15,657	4.00c	$3.63	90.8
1917	123	860,475.00	31,983,500	27,453	2.69	2.77	103.1
1920	166	1,477,963.00	59,336,900	36,496	2.50	3.51	140.0
1923	206	2,613,257.00	105,482,600	46,383	2.46	4.80	195.6
1926	242	4,176,595.00	171,797,014	58,444	2.43	6.08	250.0
1929	273	5,893,217.25	272,343,330	70,106	2.16	7.11	328.6
1930	273	6,094,871.00	287,838,022	71,873	2.11	7.15	337.8
1931	289	6,377,520.79	305,121,640	75,286	2.09	7.20	344.3

as have the number of consumers and the average monthly bill and average monthly consumption have also gone up appreciably while the average cost per kilowatt-hour has come down to some extent.

To present the picture a little more forcibly a few graphs have been



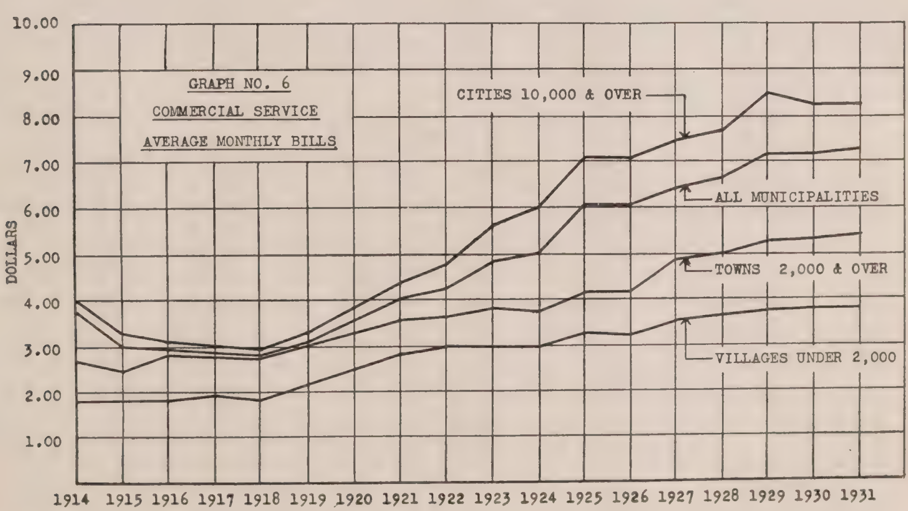
prepared which represent in a very interesting fashion the progress in the use of current and the steady decline in the cost of service as well as other interesting features.

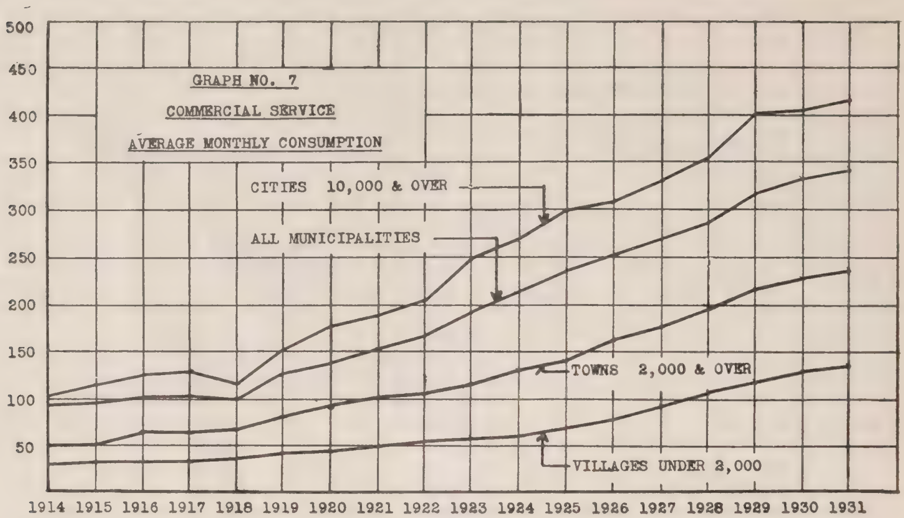
Graph No. 1 shows the average cost per kilowatt-hour in four curves covering cities, towns, villages and all municipalities combined.

Graph No. 2 shows the average monthly bills under the same classification as Graph No. 1.

Graph No. 3 shows the average monthly consumption per consumer giving the growth in average consumption for cities, towns and villages and Graph No. 4 indicates the growth of consumption among the consumers of six typical municipalities.

In Tables No. 5, 6, 7 and 8 are





presented the figures for commercial lighting service along the same lines as the previous tables for domestic service and in these tables on commercial lighting the same general increases in revenue and consumption are noted as are also the decline in the average cost per kilowatt-hour and in the average monthly consumption per consumer.

It is interesting to note that the average monthly consumption has increased in the villages whereas in domestic service there was a decrease and there is also a decrease in the average cost per kilowatt-hour among average commercial consumers as compared with an increase among average domestic consumers. It is hard to account for this particular phenomenon except perhaps for the fact that storekeepers and other commercial lighting users cannot curtail their service whether there is a depression or not.

The results of the last four Tables are also represented graphically in Graphs Nos. 5, 6 and 7 which need no further explanation.

Fifty years ago *The Electrician* of August 19, 1882, quoted the following remarks made by the then Chairman of the Gas, Light and Coke Company at the annual meeting of that undertaking: "I have never, from the time I saw it tried in Paris four or five years ago, had the least fear as to the effect of electrical illumination upon gas, and from that moment to this I have never altered my opinion. I am perfectly certain that, let them get as many Bills as they like, and as prolonged powers before they sell their properties to different corporations as they can, they will never be able to carry out what they propose."

—*The Electrician.*

Correction:—The author of the article starting on page 267 in the August number, "140-Ton Motor Operated Transfer Truck," was H. W. Wagner, and not as stated.

Application of Hydro-Electric Power to Farm Work

Article No. 26

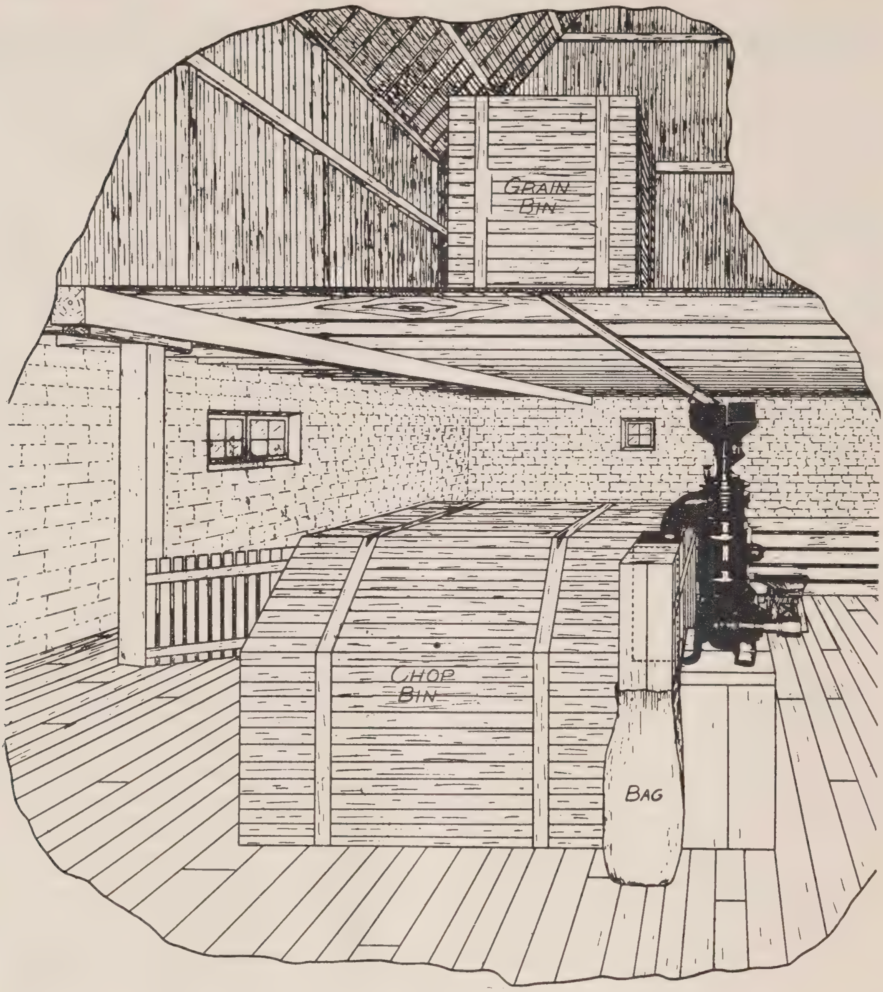
Electric Grain Grinders for Use on Farms

DURING the past few years the question of grinding grain on the farm has received very serious consideration by the Hydro-Electric Power Commission of Ontario. From studies made, it was conclusively proven that a very important saving could be made to the farmer both in cost of doing the work and time saved in handling this product, if the work were done on the farmer's premises instead of by the old method of hauling the grain to the custom mill. In many cases the amount saved would be so great as to be sufficient to pay the entire annual cost of the electric service. To the present time, however, grain grinding equipment of small sizes, available for use on farms, was low in efficiency, as the machines absorbed too much power and the quality of the product was much below the desired standard, especially for hogs and poultry.

A study of this problem was undertaken by the engineers of the Commission in the laboratory, with the purpose of discovering the fundamentals involved in grinding grain. After many experiments, it was disclosed that the type of machine offered for this purpose was of low mechanical efficiency, largely due to the fact that it was belt-driven, thereby absorbing excess power, also that it was too large and with the required prime mover, more expensive than the average farmer could afford. Investigations have proven that machines requiring less power could be evolved for this work, which would result in a decreased cost.

After long and careful investigations of existing types of plates available for chopping, it was found that the ordinary cast iron plate in general use was unsatisfactory for small sizes of grain grinders. It was evident that to produce a satisfactory quality of chop for an extended period of time, some radical changes were necessary both in the design of the plate and the material used in order that the life might be extended and the fineness controlled to give a uniform product. As a result of this the Commission has developed a new type of plate which is radically different from those in common use, and has proven by tests to be entirely satisfactory. This plate is of the toothed variety and a very different design from those previously used. It is made of a very hard alloy steel, which is highly resistant to abrasion and not too brittle, as is some times the case with very hard materials. This plate shears the grain, whereas in the old type of plate, the material is reduced by a rubbing action. The results show a considerable increase in efficiency, and the product is of a granular texture which is believed to be that desired by the farmer.

All types of grain grinders, whether using the new type of plate or not, should be protected by a suitable



Suggested set-up of farm chopper with the grain supply above and the chop box below with bagger attachment so that chop may be transferred to other buildings. When chop is being delivered to the bin no attendance is necessary.

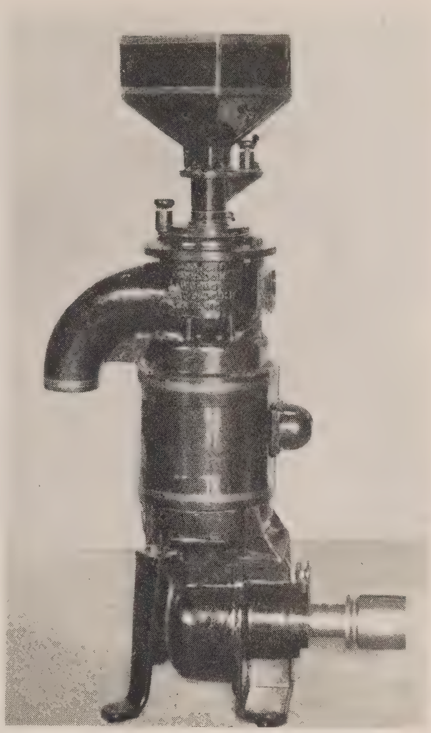
device to remove such material as nails, bolts, staples, etc., which is frequently found in grain. For this reason, magnetic protective devices were developed which should be included as part of any grain grinding equipment to prevent injury to or destruction of the plates. This is accomplished by passing the grain through a small hopper in which permanent magnets have been placed, the whole being an integral part of the machine.

A test made recently on two small machines of different manufacture, using the new type of alloy-steel toothed plate as developed by the engineers of the Commission, showed approximately the same results, as follows:

Tons of grain chopped	50
Hours of operation	343
Kilowatt-hours consumed	543
Average pounds output per hour	290
Average pounds output per kilowatt-hour	184

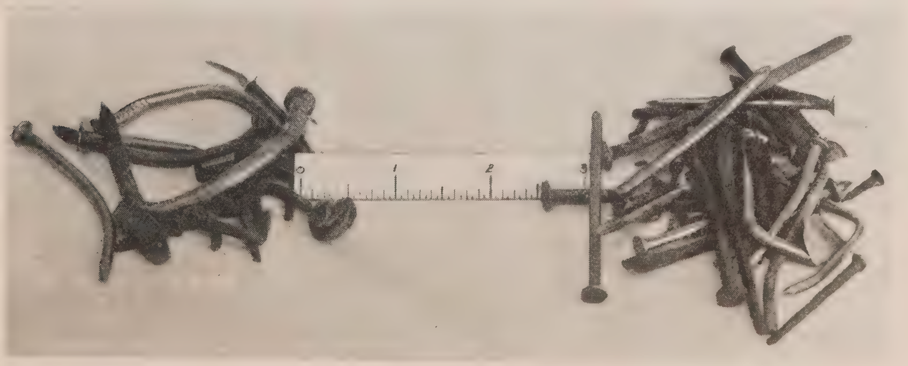
After grinding approximately 50 tons of grain by each machine, the plates used were by no means worn out, it being estimated they would satisfactorily chop an additional 25 tons. This would mean that the new type of plate as used in the test, could satisfactorily grind all the chop needed on an average Ontario farm for a period of between two and three years. It is interesting to note from the above, that under average conditions grain grinding on a Hydro-served farm in Ontario may be done at a cost of less than one cent per hundredweight.

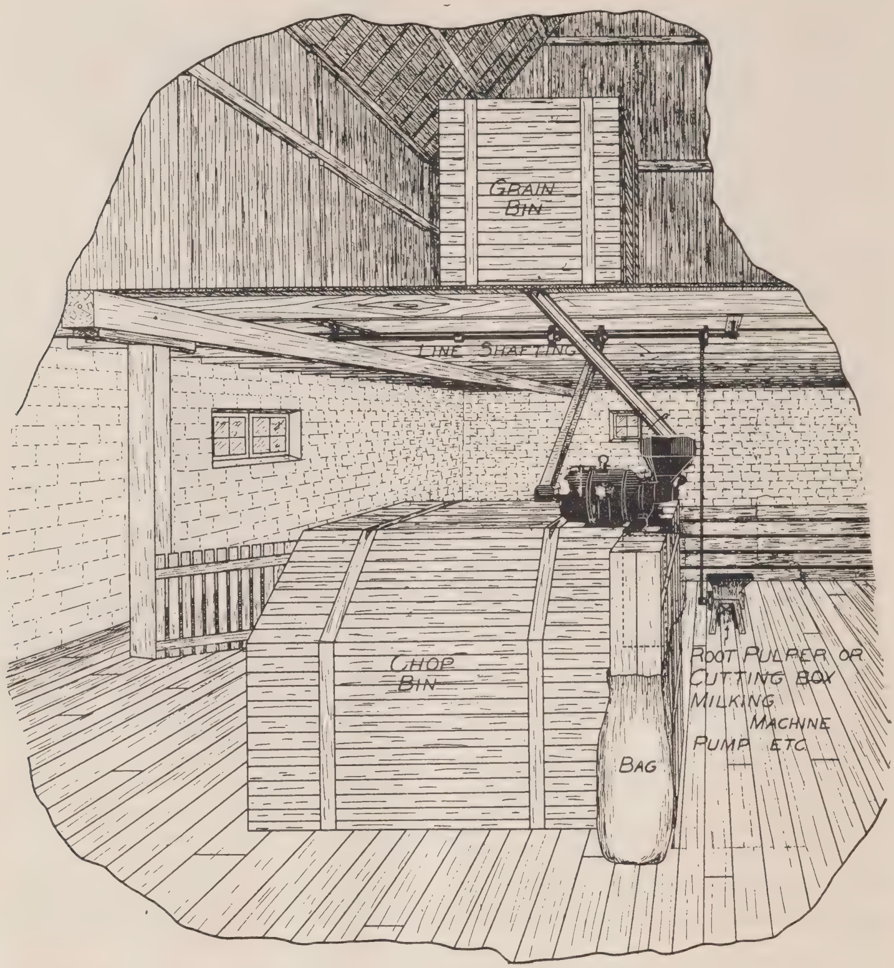
Two of these small machines are now manufactured in Ontario and available to farmers, equipped with magnetic protection and the new type of alloy-steel toothed plates, one machine being horizontal and the



Vertical electric chopper in which a 1-1/2 horsepower motor is used for 25-cycle and a 2-horsepower motor for 60-cycle service. The power take-off operates at about 1/3 of motor speed through a friction drive and clutch. The chopper plates are thrown apart when the motor is used to drive other machines through the pulley drive. This machine is manufactured by The Cockram Engineering Works, Port Dalhousie, Ont.

Below:—Some of the nails, bolts, etc., collected by magnets, when making life test run of plates on the small choppers.

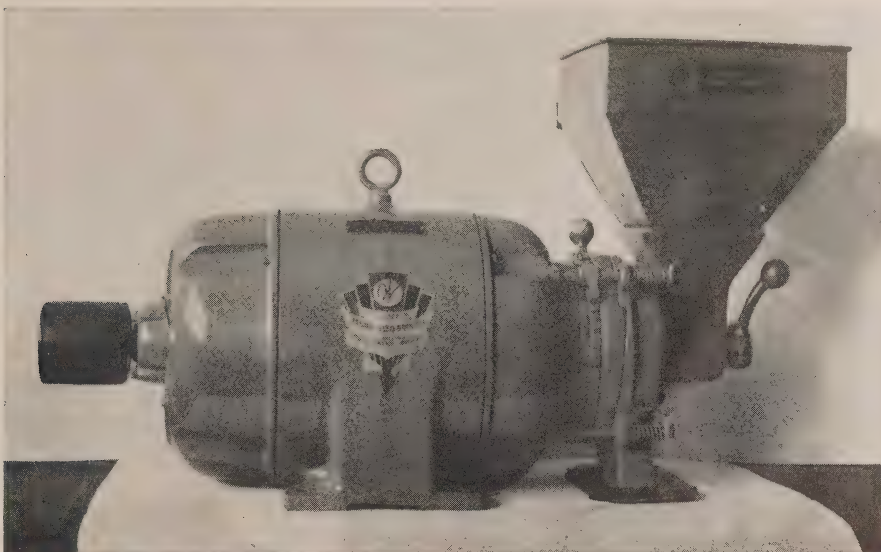




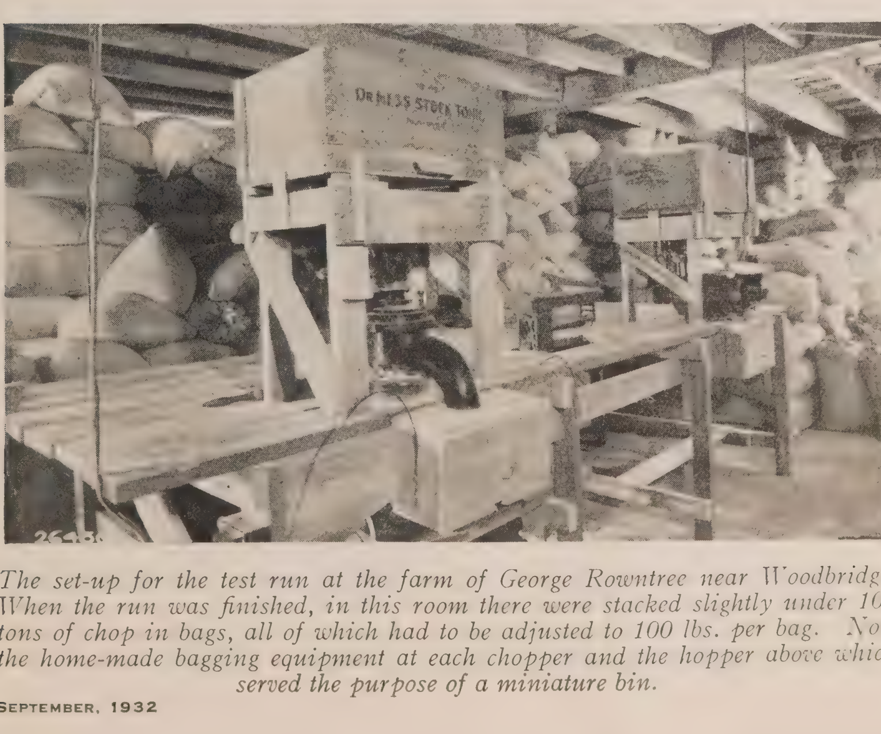
A suggested set-up of horizontal chopper, grain box, chop box, bagger, line shafting and power-using farm machinery. No attendance is necessary when chop is being delivered to the chop box.

other vertical. Both are provided with power take-off, that is, the same motor may be used for driving other farm equipment such as the milking machine, pump, cutting box, cream separator, etc. As at present constructed, each of these grinders operates with a 1½ horsepower motor, and places at the farmer's disposal a combined electric motor and grain grinder, which should, in the majority of cases, take care of nearly all the power requirements on the average Ontario farm.

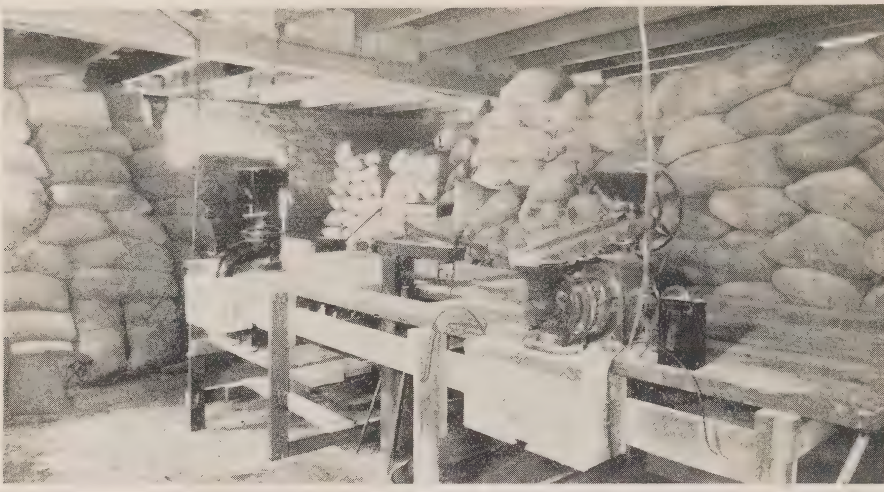
In order that farmers may become familiar with this equipment, arrangements have been made to hold demonstrations in various parts of the Province, at which representatives of the Commission will be present to



Horizontal chopper in which a 1-1/2-horsepower motor is used for 25-cycle and a 2-horsepower motor is used for 60-cycle service. The power take-off operates at motor speed. The plates are separated when using the motor for other purposes than chopping. This machine is manufactured by The W. C. Woods Company Limited, Toronto.



The set-up for the test run at the farm of George Rowntree near Woodbridge. When the run was finished, in this room there were stacked slightly under 100 tons of chop in bags, all of which had to be adjusted to 100 lbs. per bag. Note the home-made bagging equipment at each chopper and the hopper above which served the purpose of a miniature bin.



The chopper set-up without the bin arrangement. These machines were kept operating continuously from July 6th to July 23rd with the exception of Sundays, in an effort to produce in a few weeks the same quantity of chop by each machine, as would be used on the average farm in two years.

explain the uses to which these machines may be put, together with the economics concerning their operation.

These machines may be purchased on the farm loan plan as arranged by the Ontario Government several years ago. Full information with respect to the steps necessary to secure farm loans for this purpose, will be available at all rural power district offices of the Commission throughout the Province.

It is evident, therefore, that two major improvements as outlined above have made small choppers highly desirable. The new plate and the direct-connected chopper give highly efficient results both in quality of product and low cost. These economics are of great importance to Hydro-served farmers and will play an important part in assisting in the production of hogs, poultry and cattle at lower cost, thereby taking advantage of the preferences to Canada as arranged at the recent Imperial Economic Conference at Ottawa.

O.M.E.A. and A.M.E.U. CONVENTION

at the Royal York Hotel, Toronto

January 24 and 25, 1933

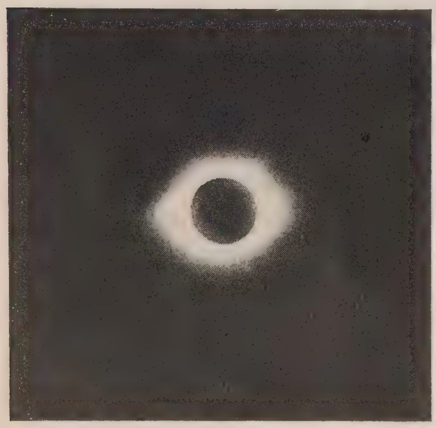
Total Solar Eclipse
August 31, 1932

CLOUDS which were quite disconcerting to the astronomers in Quebec on August 31st, were of considerable advantage to photographers. In the reproduction of the solar eclipse of that date, which appears on the front cover, screening by the clouds resulted in a very interesting view which was taken by J. C. Burkholder at St. Hugues some eight minutes after totality (3.33 p.m., E.S.T.) at a point about 8 miles from the centre line of totality.

The diamond ring,—at instant of re-appearance of sun after totality.

The following story taken from the *Ottawa Citizen* of September 1st, tells of the success of the party.

"Although many of the expeditions to view the total eclipse of the sun yesterday were comparative failures owing to clouds, two Toronto electrical engineers, J. C. Burkholder and F. K. Dalton (Hydro-Electric Power Commission of Ontario), were highly successful and obtained numerous photographs of the various stages of the eclipse.



At Centre of Totality, 3.25 p.m.. E.S.T.

"The two men, who arrived here early this morning, followed a rift in the clouds from St. Simon to St. Hugues, Quebec, and at all times were able to see the sun free from clouds.

"The party were motoring from Toronto through Montreal to Ottawa, intending to take in the path of totality en route. They had provided themselves with cameras and an instrument for measuring the light intensity. Their equipment was portable, and as the rift in the clouds moved slowly eastward they packed up and moved their instruments to follow the patch of blue sky.

"They first noticed the rift in the clouds while at St. Hyacinthe and motored along the highway until under it. There they took their first pictures just as the moon started to encroach on the sun. For 50 minutes

the sun was free from clouds and then the men moved to St. Simon. From here they motored to the far edge of the clouds at St. Hugues and there they had an uninterrupted view of the eclipse through totality and until four o'clock, when they packed up and came to Ottawa.

"During totality, they observed the sun's corona and noticed several stars out, and just after totality saw the 'diamond ring' as the sun started to appear again.

"On the road they heard roosters crowing and in one place saw cows stop grazing and going into the barn. Previous to the start of the encroachment of the moon on the sun the party overheard the remark that the eclipse was a 'fake' as there was no moon in the sky!

"The party sympathized with the expeditions that had been disappointed and said that it was purely the taking advantage of an opportunity and the fact that their equipment was portable that they were able to get their pictures."

The two illustrations showing the eclipse at totality and the diamond ring at the instant of reappearance of the sun were taken by Mr. Dalton, also at St. Hugues.

The above illustration is of a heron that flew into primary circuits south of St. Thomas and caused interruptions to both city and rural service. The dead bird measured 5 feet 6 inches by 4 feet 6 inches, and weighed about three pounds.

Association of Municipal Electrical Utilities

Minutes of Executive Committee Meeting

A meeting of the Executive Committee of the Association of Municipal Electrical Utilities was held at the office of the Hydro-Electric Power Commission of Ontario, Toronto, at 2.00 o'clock on the afternoon of Thursday, September 8th, 1932. Those present were Messrs. C. E. Schwenger, Chairman; J. W. Peart, R. L. Dobbin, R. S. King, J. C. Moors, W. M. Rogers, O. H. Scott, T. W. Brackinreid, H. T. Macdonald, W. R. Catton and S. R. A. Clement.

The Minutes of the Summer Convention at Bigwin Inn were read and adopted.

The Secretary reported conversations with Mr. T. J. Hannigan, Secretary, and Mr. C. A. Maguire, President, Ontario Municipal Electric Association, advising of their being prevented attending this meeting by unforeseen circumstances. He had been instructed that the Committee should proceed with arrangements regarding the Winter Convention of the Association, keeping in mind the requirements of the O.M.E.A. and following the same plans as had been carried out in previous years.

The Secretary also reported the absence, on account of illness of Mr. E. V. Buchanan, Chairman Papers Committee, and that there would be no report from this Committee at this time, but that the Committee proposes meeting soon after Mr. Buchanan's recovery to arrange for papers to be given at the Convention.

Mr. H. T. Macdonald, Treasurer, reported the finances of the Association to be about $700.00 better than at this time last year.

The Secretary reported having obtained tentative reservations at the Royal York Hotel, Toronto, for the Convention, the dates being January 24th and 25th, 1932. The dates suggested were approved.

Mr. T. W. Brackinreid, Chairman Convention Committee presented a report of proposed entertainment during the Convention and asked that a maximum of $250.00 be granted towards it.

It was moved by Mr. T. W. Brackinreid and seconded by Mr. O. H. Scott, THAT the Convention Committee be permitted to spend up to a maximum of $250.00 for entertainment during Convention functions. —*Carried.*

Mr. Brackinreid advised that the Committee would meet again before the Convention to make final arrangements and that any suggestions would be gladly received.

Mr. Brackinreid advised that a manufacturer had asked for the privilege of supplying badges for the Convention. It was felt that such badges which would contain advertising of a particular firm would not be desirable. It was, therefore, moved by Mr. R. L. Dobbin and seconded by Mr. T. W. Brackinreid, THAT the Association purchase its own badges.—*Carried.*

It was moved by Mr. J. W. Peart and seconded by Mr. O. H. Scott THAT the Electric Club of Toronto

be invited to attend the Convention luncheon on Wednesday, January 25th.—*Carried.*

The Secretary reported having visited Niagara Falls on the invitation of the Managing Director of the General Brock Hotel for the purpose of ascertaining whether that hotel could take care of the Summer Convention of 1933, and had incurred certain travelling expenses thereby. He also advised of the possibility of a similar invitation coming from Windsor and asked for instructions should he receive same.

It was moved by Mr. T. W. Brackinreid and seconded by Mr. W. M. Rogers, THAT the Association reimburse the Secretary for travelling expenses on account of going to Niagara Falls, and should a similar invitation come from Windsor, for travelling expenses on that trip.—*Carried.*

The nature of exhibits in the Engineering Building of the Canadian National Exhibition was discussed, pointing to the desirability of exhibits that would familiarize the general public with such phases of the work as are advisable. Reference was made to a resolution of this Committee at its meeting of April 23rd, 1932, as follows:

"THAT the Ontario Municipal Electrical Association be requested to interview the Hydro-Electric Power Commission of Ontario with a view to greater publicity along the following lines:

1. THAT space be obtained at The Canadian National Exhibition where an exhibit can be put up along the lines followed by the Canadian National Railways, the Canadian Pacific Railway, and the Bell Telephone Company with coloured illuminated maps showing the various Hydro systems, and with attendants in charge capable of answering questions concerning Hydro, both urban and rural, and with printed matter for distribution dealing with the progress and various phases of the Hydro System.

2. THAT in our opinion a Hydro magazine should be issued for distribution to light and power consumers giving information in a manner that may be of interest to laymen and eliminating technical matters. It is felt that sufficient advertising could be secured to make this self-sustaining.

"3. THAT in view of the fact that many readio stations are being operated by private concerns and others for their advantage, we feel the Hydro-Electric Power Commission of Ontario should take advantage of the opportunity to broadcast the Hydro story at frequent intervals. We feel that the Municipal Commissions and Hydro Consumers generally are not being kept as closely in touch as we believe advisable in the continued interest of Hydro progress."

It was moved by Mr. W. R. Catton and seconded by Mr. O. H. Scott, THAT the Ontario Municipal Electrical Association be asked what action has been taken on the above resolution.—*Carried.*

It was moved by Mr. O. H. Scott and seconded by Mr. J. C. Moors, THAT a Committee composed of the President, Mr. W. R. Catton and Mr. O. M. Perry inquire into the matter of exhibiting at the Canadian National

Exhibition and report to the Executive Committee.—*Carried.*

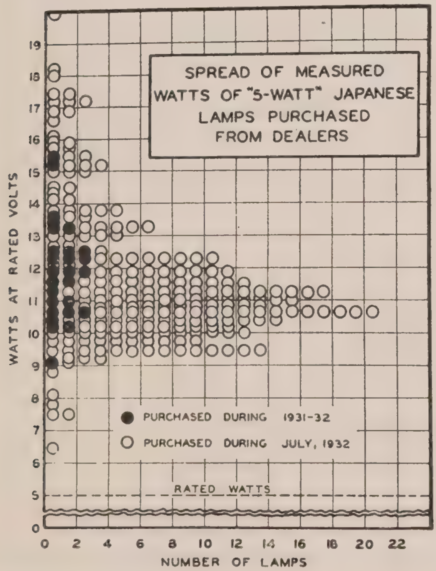
It was moved by Mr. T. W. Brackinreid and seconded by Mr. J. W. Peart, THAT a letter of sympathy be sent to Honourable I. B. Lucas on account of the death of his son.—*Carried.*

The meeting then adjourned.

Pseudo "5-Watt" Lamps

Incandescent lamps may and do vary with respect to light output and efficiency—qualities not designated on the lamp. The public, however, should be able to rely upon the substantial correctness of the watts designation which does appear on the lamp.

Recently Japanese lamps have been found upon the American market bearing "5-watt" designations. Electrical Testing Laboratories, on behalf of member companies of the Association of Edison Illumination Companies, having surveyed these products, finds that such lamps are anything but 5 watts, averaging about 12 watts and ranging as indicated in the accompanying chart.



Such misleading marking of incandescent lamps is inexcusable, these laboratories contend.

MEASUREMENTS OF WATTAGE OF JAPANESE LAMPS, RATED AT 5 WATTS, PURCHASED IN VARIOUS CITIES

City	Number Measured	Average Watts
Detroit	23	11.2
Warren	10	10.6
Boston	53	11.1
Philadelphia	24	11.8
Waterbury	11	11.9
New York	39	11.7
Chicago	13	13.9
Butte	2	11.1
St. Louis	37	12.5
Youngstown	2	13.4
	214	11.8

—*Electrical World.*

The same general condition has been found to prevail with lamps from the same source and of larger reputed wattages. The ratings, efficiencies and life of these lamps are very irregular, the life is found to be very short. Customers purchasing such lamps, though they may pay less for them than for high grade lamps, are not receiving anything like the value they would receive from Hydro Long Life Lamps, in which the ratings in watts, efficiencies and life are very closely checked. This is a strong argument in favour of Hydro Lamps over the cheap imported article.

THE BULLETIN

Published by

HYDRO-ELECTRIC POWER COMMISSION

of Ontario

190 University Ave. Toronto

Subscription Price $2.00 Per Year

Belleville Hydro's New Office Building

ON the afternoon of Monday, September 26th, the Belleville Hydro-Electric System opened its new office building with Chairman H. E. Fairfield of the Belleville Commission as Master of Ceremonies. Honorable J. R. Cooke, Chairman, Hydro-Electric Power Commission of Ontario officially opened the building, following an address by the Right Honorable Arthur Meighen, P.C., K.C., Commissioner.

Commenting editorially on the event, the "Ontario Intelligencer," Belleville, expresses the general feeling regarding this move of the Belleville System, in the following :—

"One of the most encouraging signs Belleville has seen was the large attendance of citizens who witnessed the opening of the Hydro offices on Monday afternoon. The attendance was beyond expectations, the accommodation of the second floor being taxed. This sincere tribute of citizens to the success of the local system was one which the members of the Hydro Commission appreciate.

"'Nothing succeeds like success' goes an old saying, and if ever it was true, it is true in the case of the municipally-owned Hydro System. It has been a success, paying off a large proportion of the indebtedness before it was due and having the new offices and improvements all paid for besides possessing a surplus and having made reductions in rates which have meant a cut in expenditure to the consumers of $95,000 in the three years of operation under municipal ownership.

"One of the surest signs of the progress of the utility is that the rate to the consumers will not be advanced even though the local Commission has been called upon to pay more for power to the Ontario Commission, as the result of adverse exchange rates which have been ruling for the past year. This statement by Chairman H. E. Fairfield of the Belleville Commission was welcome news to users of electricity.

"The hundreds who heard Hon. Robert Cooke, Chairman of the Ontario Commission, Right Honorable Arthur Meighen, member of the Ontario Commission, Major W.

CONTENTS

Vol. XIX No. 10
October, 1932

W. Pope, Secretary, and F. A. Gaby, Engineer of the Ontario Commission, as well as the local board members and the local manager, Mr. O. H. Scott, at the opening ceremonies and the large number who took in the unveiling on Front Street, cannot but be proud that they were privileged to participate on such an occasion. The beauty and accommodation of the building completely satisfy all.

"It has been a proud day for the members of the local Commission to see their efforts achieved and the System properly housed, and to witness such an endorsation of their efforts as the citizens manifested.

"There is one point about the building which makes it unique—the front. No one could fail to notice the effective front, recessed where fronts are generally projecting and done in material and color in complete harmony. The idea of withdrawing the show window where usually the centre is projected was a local thought and it would not be surprising to see that the idea is taken up by architects and store-owners because of the additional freedom it gives for window-shopping, free from the molestation of those who are walking past. The recessed window also accentuates the show-space within. The local Commission, with the architect and the manufacturers of the plate glass, are to be congratulated on the innovation.

"Modern decoration and construction in association with the sale of one of the world's greatest discoveries, electricity—no wonder, they go in company. Comments by those who inspected the front and the interior were complimentary of the Hydro Commission and indicative of the place which Hydro occupies in the forefront and the van of modern progress."

The new property is located in the centre of the business district of Belleville, having a frontage of 36 ft. 4 inches, on the main street, and extending to a depth of 265 feet. The buildings have a floor space of approximately 12,600 square feet and are three stories in height,—that facing the main street is 36 feet 4 inches by 80 feet, from the ground floor of which a driveway 9 feet wide is taken off.

The Hydro System will use only the main floor of this building, the two upper floors being for rent. The front part of this main floor is devoted to an Appliance Shop, which is approximately 40 feet by 25 feet. To the rear of the Shop are some of the offices, the Manager's Office and the Boardroom. Immediately to the rear is a second building 11 feet wide by 52 feet long, which is used for offices, meter-room, wash-rooms, etc.

Window Display During Opening.

Again at the rear of this is another building 34 feet by 36 feet, in which the Line Department is housed. At the rear of this latter building is a large yard, approximately 63 feet by 93 feet, with a garage 34 feet by 31 feet, which completes the property. The property is served not only by the driveway from the front, but also by a driveway from the street to the rear.

The buildings will be electrically heated by a hot water system. In this a tank of 500-gallon capacity will be maintained at a temperature of 200 degrees by electric immersion heaters, thermostatically - controlled and also controlled so as to be kept off during peak load periods. The hot water from the storage tank is mixed with the return water from the radiating system, by a mixing valve, which can be set for any temperature required, between 100° and 200° and forced through the radiation system by a small pump, having a capacity of 15 gallons per minute. This pump is controlled by a thermostat in the office.

The display window is of the very latest design, being recessed and trimmed with aluminum alloy and oxonolite. The centre of the window is 3½ feet from the inner edge of the sidewalk, while the entrance doors are but 2 feet from this line. The lighting installation of the windows and offices was designed by the Illumination Laboratory of the Hydro-Electric Power Commission of Ontario

This move on the part of the Belleville Hydro-Electric System reflects credit to the local Commission, which is made up of the following,—H. E. Fairfield, Chairman, Chas. E. Hanna (deceased), Commissioner, and Geo. O. Tice, Mayor. Oswald H. Scott is Manager and Secretary.

The Bulletin congratulates the Belleville Commission on having such a creditable building.

The Sale of Surplus Power

(A statement by the Hydro-Electric Power Commission of Ontario issued for publication on October 19, 1932.)

THE Hydro-Electric Power Commission of Ontario has been able to complete a contract for the sale of a substantial amount of surplus power. It is important that the special circumstances which appertain to this class of power and its sale should not be misunderstood.

In its Annual Reports, the Commission has drawn attention to the fact that in order to secure continuity of electrical service, it is necessary to maintain in the generating stations a margin between the total installed capacity and the anticipated peak load. In most electrical undertakings this reserve capacity, maintained to permit overhaul of units and to meet emergencies, is called upon for relatively only a few hours in the year. There are also times of daily and seasonal peaks, and since the equipment provided must be capable of taking care of the maximum demand for power whenever it may occur, some additional equipment must be idle during "off-peak" periods, unless a market can be found for the surplus power at such times as it may be available.

In published statements the Commission has explained the outstanding characteristics of surplus power, that is to say, as to whether it is "firm" surplus power available over certain definite periods ; whether it is "uninterruptible" under certain conditions; or whether it is "at will" surplus power,—the last-named being a supply with respect to which the vendor assumes no obligation to furnish the power except as it may be available after precedence has been accorded to all other demands upon its equipment.

In connection with the disposal of surplus power, Canadian consumers are given priority of consideration. The chief market for Niagara surplus power has hitherto been in adjacent territory in the United States served by power supply systems securing at least a large proportion of their power from steam plants. The Commission, for a number of years, through a Canadian subsidiary of a large Company in the United States, was able to dispose of surplus power which produced a revenue of about $1,000,000 per year. This transaction involved but little additional operating cost and the revenue resulted in a reduction in the cost of power to Ontario municipalities.

About two years ago—due to lessened industrial activity in the United States—there resulted a serious curtailment in and final loss of the sale of surplus power ; and since that time the Commission has been exerting every possible effort to find a suitable alternative market.

The Commission's position with respect to surplus power has been rendered more difficult first because, in addition to the loss of off-peak and surplus customers, prevailing economic conditions in Ontario have reduced the amount of power normally utilized by the industries of the Province ; and second, because

some of the supply of new power which, — upon estimated growth it had reason to believe was conservative, —the Commission had arranged would become progressively available, is not at present required and thus has temporarily been added to the surplus resulting from other circumstances. The Commission has believed that, if some of the large industries in Ontario could be induced to replace the coal they were using for the development of steam, by electrical energy, the Commission could thereby regain some of the revenue it had lost and in so doing would really be obtaining a revenue from that which would otherwise be going to waste.

An opportunity recently occurred to negotiate such an arrangement with the Ontario Paper Company of Thorold, a concern which uses a large amount of coal imported from the United States. It was shown that this company would find it to its advantage to substitute electrical energy ; that the Commission could receive a substantial revenue ; and that there would be retained in Canada funds which otherwise would have had to go outside of the country for the purchase of imported coal.

Surplus power, if it is to be saleable, has usually to be sold at especially low rates. For large quantities exceptionally low rates have to be granted. In the case of electricity for steam generation the governing feature demanding a low rate is the cost of the competitive factor of coal or other heating agent.

The Commission has now consummated a contract with the Ontario Paper Company from which the Commission will receive revenue of from $250,000 to $300,000 per annum. In order to secure this contract and at the same time preserve the independence of the Commission with regard to its surplus power so that, should need arise, it may immeddiately be diverted to more profitable industrial uses, the Commission has undertaken to provide the electrical equipment required to deliver the surplus energy in usable form for steam purposes. While the Commission is thus protected, the Company, on its side of the contract, must pay for the surplus power for a sufficient time to enable the Commission to receive revenue adequate to retire the whole of its capital investment for the extra equipment, —which equipment will entail an expenditure of about $325,000. In this connection, it may be explained that the transformers and other electrical equipment thus required may, with relatively little expense, be adapted for other uses in the Commission's general work, and it is not amiss to add that in the construction of this equipment, money will be spent for Canadian material and labour which, under the prevailing circumstances, will constitute a great relief to many.

Provincial Plowing Match Demonstration at Ottawa

October 11 to 14, 1932

AT the request of the Provincial Plowmen's Association, the Commission this year again set up a demonstration at the Experimental Farm at Ottawa, where the plowing match was held.

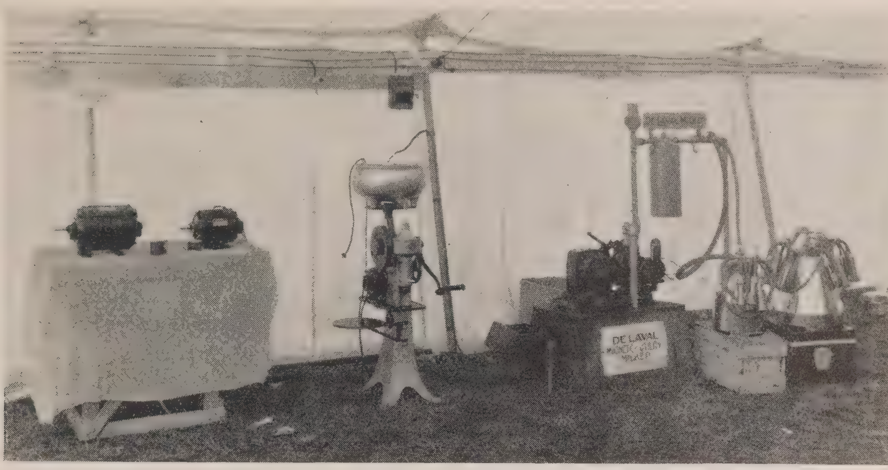
As in the past years, the set-up consisted of two distinct divisions, one displaying equipment for use in the home, such as table appliances, ranges, washing machines, ironers, etc., and in the other section machinery and equipment for use in the barn and dairy. The whole display was housed in one tent 40 feet by 60 feet, divided by a partition between the two sections. The display consisted of equipment which is new to the farming public and of the latest development.

Of special interest to the farmer were the two individual types of electric chopping units, a vertical one and a horizontal one, as well as the chopper formerly used in which the motor is belted to the chopper. Both these new units have the chopper head built directly onto the motor and a power take-off arrangement so that the motor may be available for other purposes when not needed for chopping.

In another section, a four-can milk cooler, self-contained and automatic, of the direct-expansion type, using plain water as a cooling medium, was on display and in operation.

Another section was devoted to the display of full lines of water-pumping equipment, for both shallow and deep

His Excellency the Right Honourable The Earl of Bessborough, Governor-General of Canada, officially opened the contests of the match by plowing a furrow.



A self-contained motorized milking machine unit, an electrically operated cream separator and two electric motors which were dismantled to familiarize farmers with the working parts.

wells, automatically or manually controlled.

Cream separators and milking machines of a well-known make, and embodying the latest improvements, were on display.

For the purpose of education, two small motors were displayed dismantled to familiarize the farmer with the working parts and requirements as to care and cleanliness.

Great interest was shown in all the machinery on exhibit, but probably was focused mostly on the individual chopper and the new Hydro plates which were displayed in pairs. One

A section of the farm machinery side of the demonstration, showing pumping equipment and milk cooler, also the stove with its underground flue operated by an electrically operated suction draft.

The horizontal electric chopper with its line shafting and some machinery to which this power may be applied. The vertical direct-connected chopper with two pieces of farm machinery belted to the power take-off. A belted chopper unit with a 3-horsepower motor and 8-inch plates. The Hydro plates display showing the pair which were used in the 50-ton life test run.

pair was a suggested design for very fine chop; another the pattern now used in demonstrations throughout the country; while a third was a suggested design for high capacity plates where fine product is not required. It would seem from the interest in this feature of the display, that farmers have in mind some benefits to be derived from the Imperial Conference held recently at Ottawa.

The milk cooler attracted a great deal of attention. Many of the farmers appreciate that stiffer regulations may come into effect whereby milk cooling will be imperative. The use of ice at the rate required to meet standards now in force for certified milk, call for such quantities that some of the farmers expressed themselves as believing it would not be possible to store sufficient ice to meet the requirements without great trouble and expense, and were very pleased to find milk coolers available at reasonable cost.

Pumping equipment is always interesting to farmers, especially those who have had the experience of pumping water by hand for herds of cattle. This feature of the display proved interesting to many.

The Commission's tent and the headquarters formed a centre from which radiated two streets. Along these farm machinery demonstrations and cafeterias were arranged.

The plowing match was officially opened by His Excellency the Governor-General of Canada, The Earl of Bessborough, by plowing a furrow, in which he showed he was quite familiar with the implement in hand.

On Thursday afternoon a visit was paid to the fields where the contests were being held and to the demonstration areas by the Premier, the Rt. Hon. R. B. Bennett, the Hon. R. Weir, Federal Minister of Agriculture, the Hon. Col. J. A. Kennedy, Minister of Agriculture for Ontario, as well as other Cabinet ministers and members of Parliament. The visit of Government officials lent an air of dignity

A section of the household side showing washing machines, electric ranges, etc., each the latest in its line.

to this contest in what is considered a most important farm operation.

The contest was terminated by a banquet at the Chateau Laurier for the plowmen and guests, at which about 500 were present when prizes were presented to the winners. Among the guests at the head table were the Hon. Col. J. A. Kennedy, Minister of Agriculture for Ontario, the Hon. A. Godbout, Minister of Agriculture for Quebec, and Wm. F. Garland, member of Parliament for Carlton County, who acted as chairman.

In answer to the toast to the plowmen by the Federal Minister of Agriculture, Mr. J. J. Duffus, in his speech on behalf of the plowmen, made public acknowledgement of the

Another section in the household appliance side showing washing machines, electric ironers, ranges, table appliances, coal blowers, etc., all having their distinctive features.

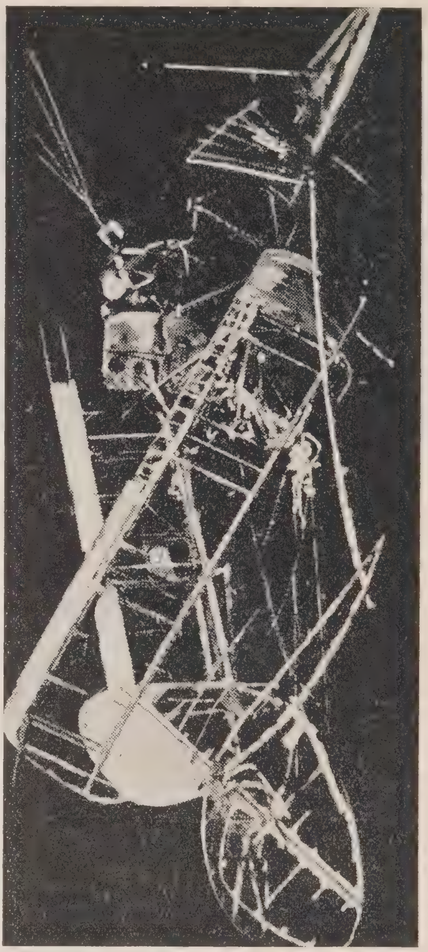
help by the Commission in making a success of Provincial plowing matches.

Among the prizes donated were included those of the Chairman of this Commission, the Hon. J. R. Cooke, to the winners of the contest in tractor class No. 2. The winner of the first prize of the five donated by him was apparently a very popular young man from Scarboro Township, Mr. Harry Jarvis. The four other prize winners were also young men.

In past years "old-timers" were generally the prize winners at these contests, but on this occasion the Honorable Ministers of Agriculture, Members of Parliament and others commented on the youth and splendid manhood of those who received the awards.

Accident to 110 Kv. Line by Aeroplane

Until recently, Ontario has been very fortunate regarding the continuous supply of electricity to customers, in relation to the movement of aeroplanes. On the evening of October 6th, just after dusk, there was an accident near London that resulted in an interruption in that part of the Province. The accident was to the Commission's 110 kv. tie line between London and St. Thomas transformer stations, when two young Londoners attempting a forced landing with their plane in a field in Westminster Township near Pond Mills south of London, flew into the line causing a short circuit. The plane, which was entangled in the power lines took fire, the illustration (from the Border



Charred wreckage of aeroplane hanging from transmission line.

Cities *Star*) showing the charred wreckage still hanging from the Hydro transmission line, the tail being entangled in four cables. The occupants of the plane made their escape by dropping to the ground a distance of 35 feet where they were found by rescuers and removed to a London hospital.

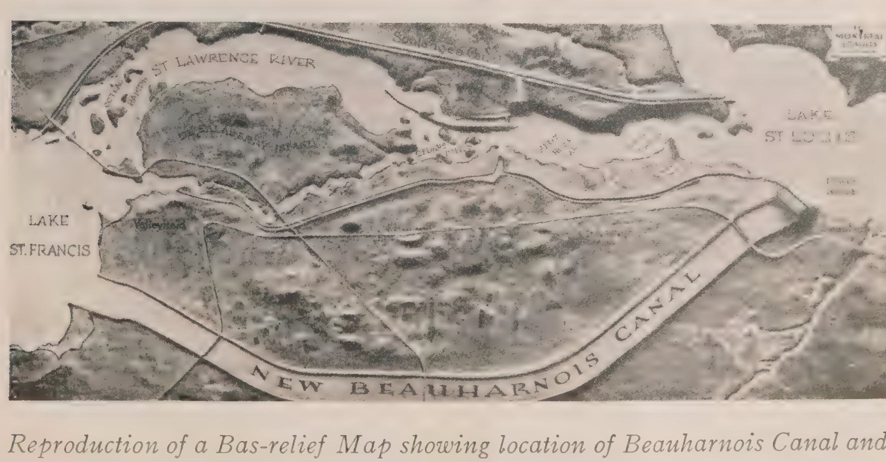
Beauharnois Power Arrives

POWER from the Beauharnois development on the St. Lawrence River was first received by the Hydro-Electric Power Commission of Ontario on October 13th, 1932. This power is delivered to the Commission by the Beauharnois Power Corporation at the Ontario-Quebec boundary, north of Lake St. Francis, at 240,000 volts, 25 cycles. From this point the Commission carries it to the Chats Falls development and from that point to the Toronto-Leaside transformer station.

The Beauharnois development is located on the section of the St. Lawrence River between Lake St. Francis and Lake St. Louis, and which is entirely within Canada. In this section there is a drop of 83 feet and a power potentiality of 2,000,000 horsepower, or 40 per cent. of the total potential power of the entire St. Lawrence River.

The route chosen for the canal, which is eventually intended for navigation as well as power purposes, is over an area of marine clay with boulder clay outcroppings underlying the top soil, excepting at the edge of Lake St. Louis, where there is ledge rock. This area is below the present level of Lake St. Francis, protected by dykes along the east end of the lake. This difference of levels permitted the construction of the canal by the erection of dykes and dredging. The canal so constructed is 15 miles in length with a minimum width at the bottom of the ship channel of 600 feet and a maximum of 3,000 feet at water level.

The power house is located on the ledge rock at the edge of Lake St. Louis. Provision is made for a total of fourteen 50,000 horsepower units of which two 60-cycle and two 25-cycle are now installed. The generators are the largest diameter machines ever built in Canada, that dimension being 40 feet. The initial two 25-cycle generators are 43,882-kv-a., 13,300-volt and 75 revolutions per minute, and are paired to feed one



Reproduction of a Bas-relief Map showing location of Beauharnois Canal and Power Development.

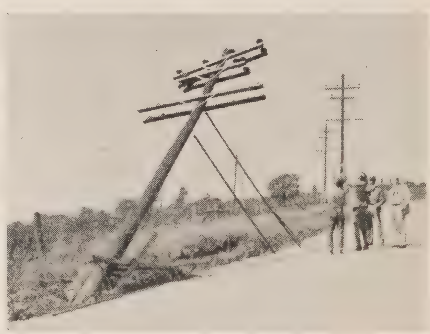
Downstream side of the Beauharnois Power House.

bank of transformers. This bank consists of three 29,250-kv-a., 125,-866/13,200-volt, single-phase transformers having separate 13.2-kv. windings for each generator. The two 60-cycle generators are 46,625-kv-a., 13,200-volt and 75 revolutions per minute and are each connected to a three-phase, 120,000/13,200-volt, 46,-500 kv-a. transformer. In addition there are two service units identical in appearance with the large machines each rated 7,200-kv-a., 13,200-volt, 60-cycle and 180 revolutions per minute.

The power house houses the generators, low-tension buses and relay and metering equipment only, the transformers, high-tension switching, and buses being located on the roof.

The Beauharnois development uses the present levels of Lakes St. Francis and St. Louis so does not interfere with any present works depending on them. Nor is any property affected by the development excepting the areas used for the canal, power house and other works, all of which have been set aside for that purpose.

On Sunday, October 9th, the voltage in Forest rural power district and the Villages of Thedford and Arkona was changed from 4,000 to 8,000 volts. This was done to supply better service and to permit the taking on of a cold storage plant in Thedford. The plant will be used to store and cool celery grown in the district and has a connected load of 100 horsepower, with a full seasonal demand during October and November and a partial demand during December and January.



The illustration above is of an accident to a pole of the Commission's 13.2 kv. line between Woodstock and Tillsonburg when on September 15th, it was struck by a heavy milk truck and carried to the position shown.

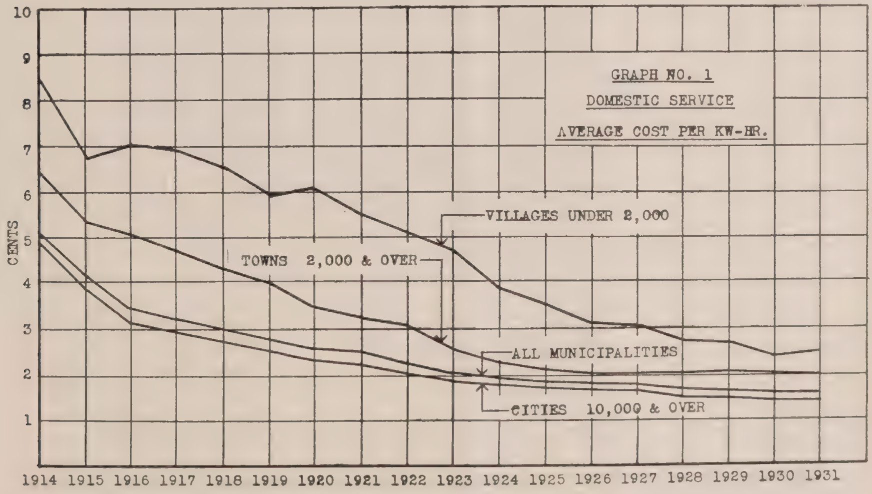
Promotional Rates

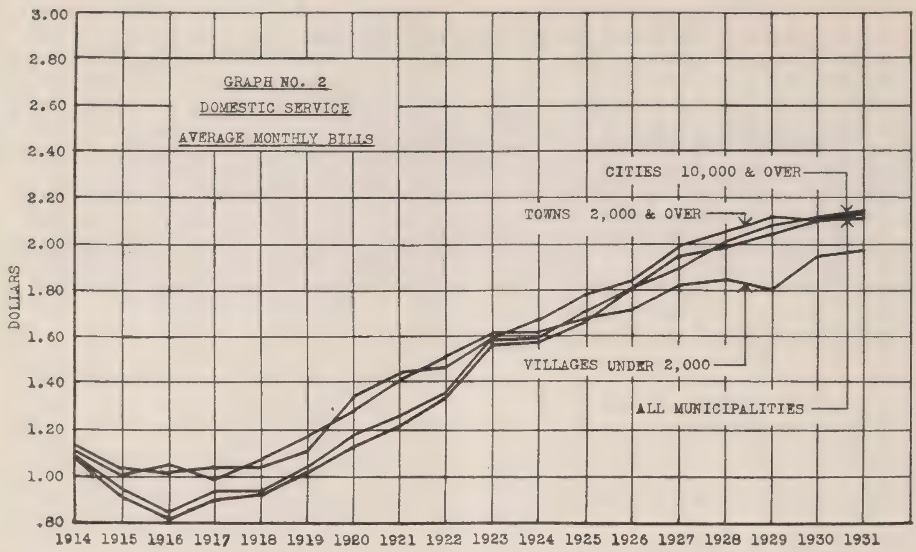
IN the September number of this publication there was an article entitled "Use of Power by Hydro Domestic and Commercial Consumers up to the end of 1931." This was illustrated by tabulations and charts so as to show the trend of consumption and revenue over a considerable period of Hydro operation.

Since the beginning Hydro Utilities have used rates of the so-called promotional form for lighting and power services. Three graphs from the former article are reproduced herein to illustrate the general trend,—(1) of the cost per killowatt-hour; (2) of the average monthly bills, and (3) of the average monthly consumption during the period covered as applied to domestic service. Since this form of rate was inaugurated at the beginning of Hydro operation, it is impossible to make a comparison between the figures shown in the graphs and what might have been had the older forms of rates been used.

It is recognized that a promotional rate will from its design develop a decreasing unit cost with an increasing number of kilowatt-hours taken by the consumer. The graphs show such to have been the result under Hydro service.

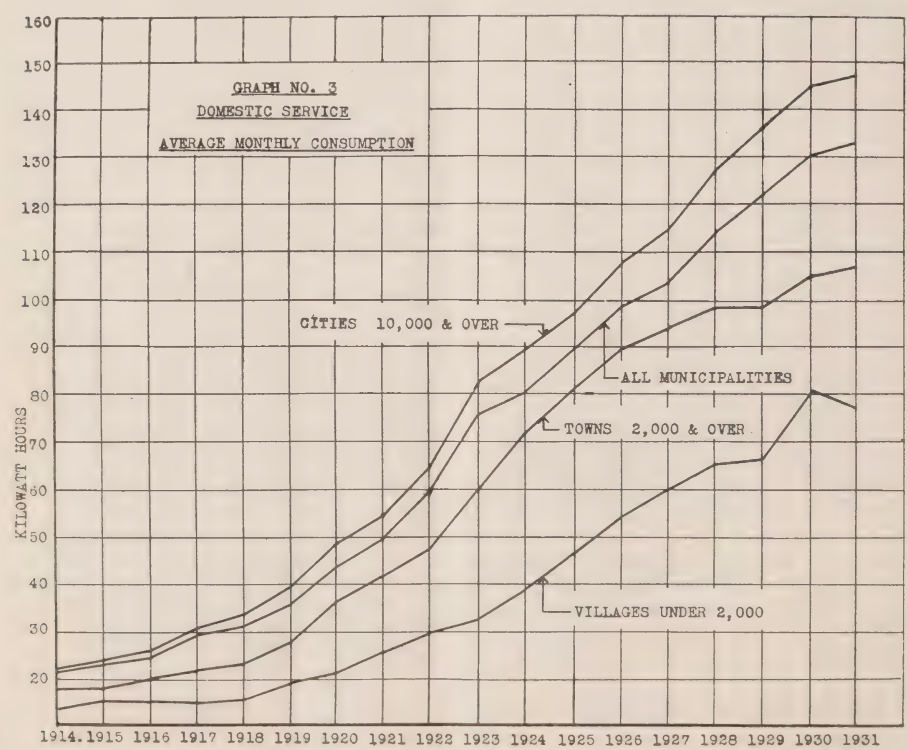
In graph 1 it is shown that between the years 1914 and 1931 the average cost per kilowatt-hour in all municipalities has decreased from 5.08c to 1.59c. During the same period the average monthly consumption increased from 21 to 133 kilowatt-hours. The average monthly bills over the same period have increased from $1.06 to $2.12. In other words, although the average monthly bills have doubled during the period, the average monthly kilowatt-hours are over six times as great. The condition illustrated has, no doubt, been caused to a great extent by the use of the promotional form of rate.

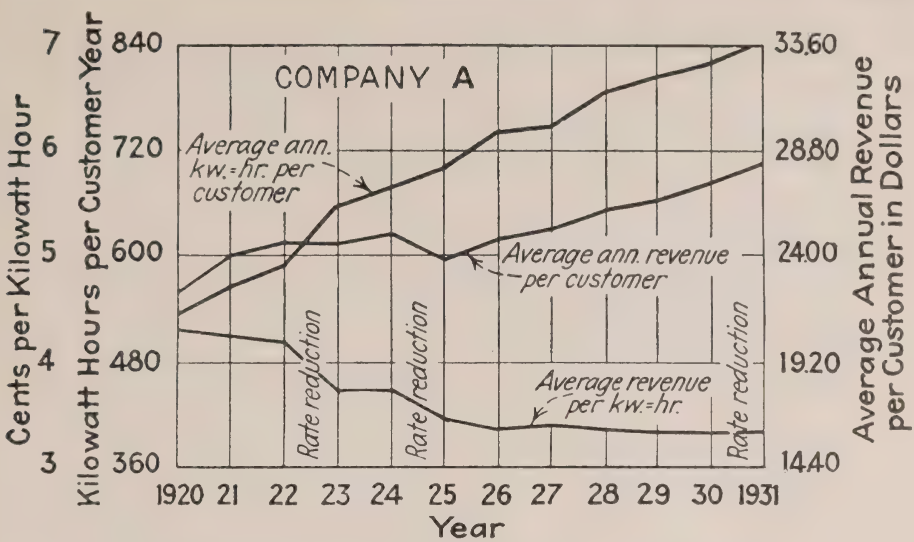




This is borne out in the information following, which has been obtained from an article in the *Electrical World* by C. F. Lacombe of Lacombe and Leffler, New York.

In his article, Mr. Lacombe gives





data regarding three particular companies operating in the United States that have used promotional rates for sufficient time to permit a study being made of the conditions. The statistics of information given by Mr. Lacombe is as in the following :

Eleven Years' Experience with Promotional Rate (Company A)

The promotional rate started about 1914. Of particular interest is the steady gain of use per customer. The revenue-per-customer line would have shown the same persistent gain as the kilowatt-hours-per-customer line except that voluntary reductions of 1 cent per kilowatt-hour were made in the first rate step in 1923 and 1925. The 1923 rate reduction produced a marked increase in kilowatt-hours per customer, but that of 1925 was not so effective, probably because the percentage of customers using energy under the first step only had decreased under the general promotional effect. The demand requirements of the rate are such that 75 per cent. of the customers can reach the second step of the rate.

The rate in 1921, with discount, was 7 cents per kilowatt-hour for the first 60 hours' use of demand, 4 cents for the next 120 hours' use and 1½ cents for the excess used. The rate in 1931, with discount, was 5 cents per kilowatt-hour for the first 60 hours' use of demand and the other steps remain unchanged. The demand requirements were quite low and other factors of the rate were unchanged during the period shown.

Kilowatt-Hours Sold

Year	Total Domestic	Per Customer
1921	42,304,000	564
1931	124,267,985	842
Increase	81,963,985	278
Per cent. increase	193.7	49.3

REVENUE PER CUSTOMER (AVERAGE)

	Annual	Monthly
1921	$24.00	$2.00
1931	28.07	2.34
Increase	$4.07	$0.34
Per cent. increase	17	17

PRICE PER KILOWATT-HOUR (AVERAGE)

1921, 4.3 cents ; 1931, 3.3 cents ; decrease 1.0 cent—23.5 per cent.

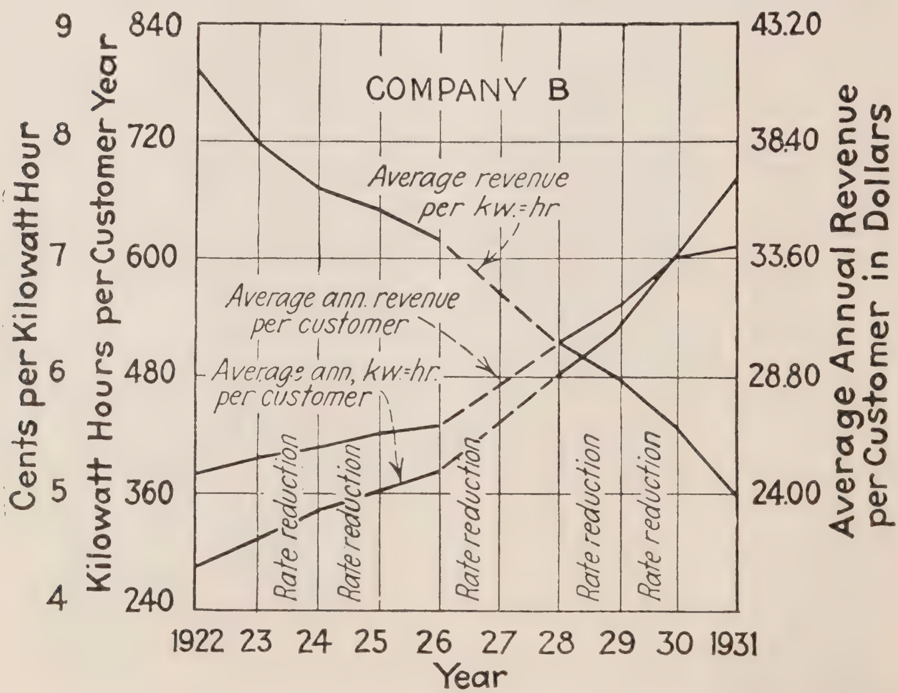
NUMBER OF CUSTOMERS (AVERAGE)

1921, 75,000 ; 1931, 147,550 ; increase 72,550—97 per cent.

NINE YEARS' PROGRESS WITH A PROMOTIONAL RATE (COMPANY B)

The promotional rate started in 1922. Except for the primary change from the straight-line rate in 1921, all the rate reductions were made in the second and third steps of the rate. The rates are of the area type and cannot be stated separately without too much repetition.

At the end of 1930 a rate for complete domestic service (lighting, refrigeration, cooking and water heating) was instituted. For a household of 1,200 sq. ft. rating the rate was $1.50 demand charge, 3 cents per kilowatt-hour for the first 200 kilowatt-hours and 1½ cents for excess



use. If the 1½-cent rate is used for water heaters 85 per cent. of the use must be off-peak. There is also a separately metered rate for 85 per cent. off-peak water heating alone, of 1 cent per kilowatt-hour. These rates are so designed that 60 per cent. or 34,100 of the customers can reach the second step of the rate.

KILOWATT-HOURS SOLD

Year	Total Domestic	Per Customer
1922	9,036,023	287
1931	38,675,530	680
Increase	29,639,507	393
Per cent. increase	328	136.9

REVENUE PER CUSTOMER (AVERAGE)

Year	Annual	Monthly
1922	$24.83	$2.07
1931	33.95	2.83
Increase	9.12	0.76
Per cent. increase	36.7	36.7

PRICE PER KILOWATT-HOUR (AVERAGE)

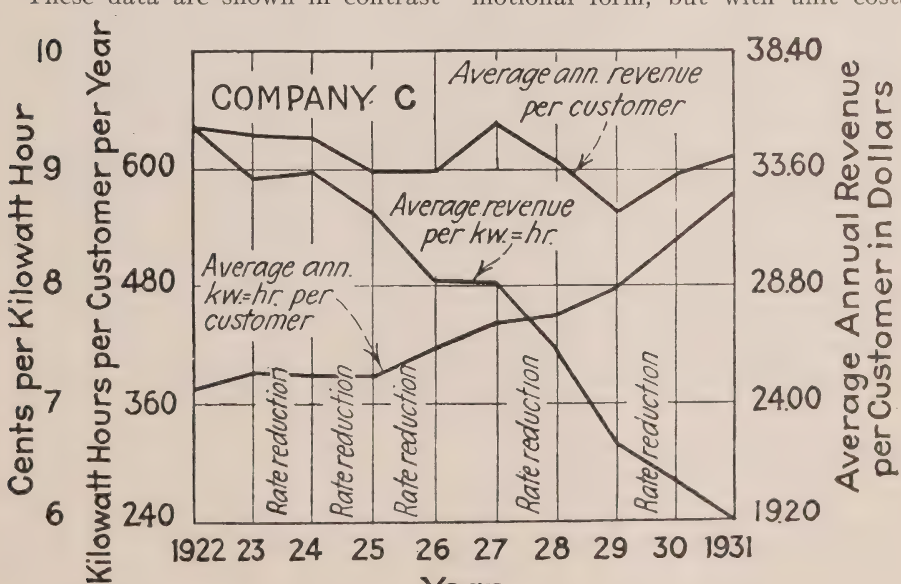
1922, 8.53 cents; 1931, 5 cents; decrease, 3.53 cents—41.5 per cent.

NUMBER OF CUSTOMERS (AVERAGE)

1922, 31,441; 1931, 56,859; increase, 80.8 per cent.

NINE YEARS' EXPERIENCE WITH DOMESTIC SERVICE (COMPANY C)

These data are shown in contrast with companies A and B. In the last five years the rates of this company have taken a preliminary promotional form, but with unit costs



too high to develop more than partial progress toward results obtained under promotional rates by Companies A and B.

The results up to about 1928 were obtained from a two-rate, two-meter system—one for lighting and one for refrigeration, cooking, etc. At that time a new rate superseded the old and most installations went on one rate and one meter. The results are not segregated, so comparison can be made of the conditions before and after the promotional rates.

The rate now being used is about 7½ cents per kilowatt-hour for the first 25 kilowatt-hours, 5 cents for the next 75 kilowatt-hours and 3 cents per kilowatt-hour for all excess. The second and third steps are too high to obtain real promotional effects because they are above the critical prices per kilowatt-hour found necessary for ranges and water heaters in general practice. They are also too high to compete with other sources of domestic service for small incomes.

* * * *

Combined with the adoption at the very beginning of the promotional form of rate was the application of the policy of service at cost. The revenues from the increased use of power, encouraged by the promotional rates, being in excess of the cost of operation, rate reductions became necessary. The rate reductions also encouraged the greater use of power and when applied to promotional rates combined to encourage the much greater use illustrated in the graphs of Hydro service.

KILOWATT-HOURS SOLD

Year	Total Domestic	Per Customer
1922	36,499,994	375
1931	167,543,336	571
Increase	131,043,362	196
Per cent. increase	359	52.3

REVENUE PER CUSTOMER (AVERAGE)

	Annual	Monthly
1922	$35.23	$2.93
1931	33.85	2.82
Decrease	$1.38	$0.11
Per cent. decrease	3.9	3.9

PRICE PER KILOWATT-HOUR (AVERAGE)

1922, 9.38 cents; 1931, 5.93 cents; decrease, 3.45 cents—36.8 per cent.

NUMBER OF CUSTOMERS (AVERAGE)

1922, 97,187; 1931, 293,283; increase, 201.8 per cent.

220 Kv. Lightning Arrester Installation at Toronto-Leaside Station

By C. F. Publow, Assistant Engineer, Electrical Engineering Department, H.E.P.C. of Ont.

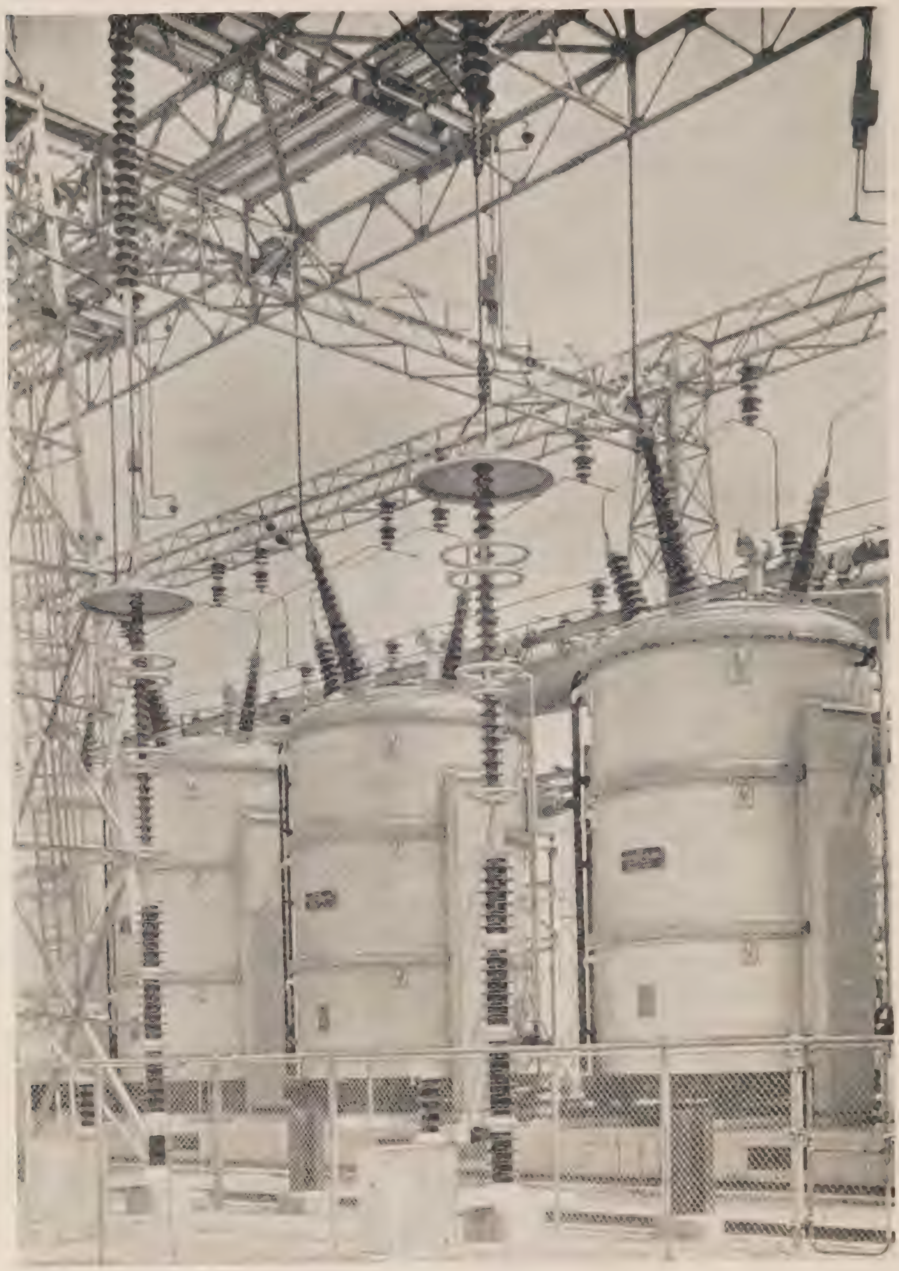
AT the Hydro-Electric Power Commission of Ontario's Toronto - Leaside transformer station, there are 3-phase lightning arresters installed to protect the 220 kv. windings of the transformer banks. Four of these were placed in service during 1930 and are of the auto valve disc type design, while the other two are of the auto valve porous-block type and have just recently been installed. They were all placed as close to the transformers as physically possible (less than 100 circuit feet).

Usually arresters are chosen with a voltage rating (from phase to ground) slightly greater than the maximum dynamic voltage which may occur where they are located on the system. However, this provides only a limited protection, especially on hydro-electric systems with long transmission lines, and while it is recognized as good practice for systems of moderately high voltage, it is questioned on 220 kv. systems where the arresters are primarily for the protection of the transformers. The arresters at Leaside have a maximum voltage rating of 268 kv. (from phase to ground), but are equipped on each phase leg with an electrically-operated switch (for opening only) which short-circuits a portion of the arrester stack to decrease its rating to 219 kv. This switching arrangement enables the voltage, which the arrester will allow at its terminals, to be reduced from approximately 1,000 kv. to 800 kv. and thus offers an appreciable additional margin of safety against incipient damage to the transformer insultation by lightning. The extra expense and complication of these disconnecting switches is thereby warranted.

These switches are automatically controlled by a potential relay which functions on dynamic voltage and inserts the short-circuited portion of the stack into the discharge path of the arrester when the system voltage arises above a pre-determined value. In this way, the arresters are protected if a spill-over should occur on their gaps at such a time. The opening of these switches is indicated in the control room on the station annunciator, and the operator arranges to have them closed promptly after the voltage returns to normal. To date, there has not been an operation of these switches under the conditions for which they were provided.

The practice followed at Leaside is to have the short-circuiting switches closed continuously only during the lightning season ; at other times they are closed only when there is a lightning storm in the vicinity to avoid the hazard of non-operation at a critical time.

From the accompanying illustration it is readily seen that radical changes have been made in the design of this protective equipment in the past two years ; the latest



No. 5 transformer bank at Toronto-Leaside station equipped with auto-valve porous block type lightning arresters for 220 kv. service.

changes permit of a much more compact and attractive layout. A number of the outstanding differences are as follows :

Toronto-Leaside transformer station showing transformer banks Nos. 3, 4, 5 and 6 with associated lightning arresters protecting their 220 kv. windings. The arresters are designed for dual voltages, those at the left are of the auto-valve porous type and of recent design, while those to the right are of the earlier auto-valve disc type design.

1. *The Gap:* On the latest arrester the gap is of the multiple series type "sealed in" in a corrugated porcelain tube divided into three sections for structural reasons, shielded with varying diameter grading rings and protected with a simple hood covering, the whole being readily suspended. On the earlier arrester, the gap consists of two spheroids covered with a large hood.

2. *The Stack:* The use of porous blocks gives a shorter, self-supporting arrester stack proper in the latest type, whereas the stack of the earlier type requires strings of insulators to "stay it" and with the gap requires a steel framework to support them.

3. *The Short - Circuiting Disconnecting Switch:* In the latest type, it is totally enclosed, the break being located in the corrugated porcelain tube mounted on the top of the mechanism housing. As it is light in construction, it has considerably faster operating characteristics — about 1/4 second as compared with 1/2 second.

It will also be noted that each phase of all the arresters is paralleled with a "spillway" gap which is set at 56 in. spacing. This setting being co-ordinated with the arrester "ceiling" voltage so that the majority of discharges through the arrester will not allow the voltage at the associated "spillway" gap to rise high enough to cause it to spillover.

In an effort to obtain first-hand data on the voltage and current values of lightning discharges, klydonographs have been installed on potentiometers adjacent to each transformer and also in the discharge path of each arrester stack when

the short-circuiting switch is closed. There have not yet been any records obtained from these. Klydonographs, have also been located on two of the incoming 220 kv. lines adjacent to the station. Several records of lightning were registered on these prior to the installation of the arresters, but there has not been any since.

—*Electrical News and Engineering.*

Too Many Violations of Code in Installation Work

BELIEVING that it would be of interest to learn how well (or how badly) the rules and regulations governing electrical installations for buildings as laid down in the Canadian Electrical Code, are adhered to in the first instance by electrical contractors and electricians generally, Electrical News and Engineering secured the co-operation of the Electrical Inspection Department of the Hydro-Electric Power Commission of Ontario.

For one month (July 1 to July 31) records were kept of the number of violations of the Canadian Electrical Code reported by inspectors in the district of Toronto and for which defect slips were issued.

It is amazing to note that the rule violated the greatest number of times was that governing the mechanical execution of the work. Section E of Rule 203, to which we refer, was violated no less than 384 times! To refresh the memory of some of our readers, this Section reads:

"In all electrical installations special attention shall be paid to the mechanical execution of the work. Careful and neat running, connecting, soldering, taping of *conductors*, and securing and attaching of equipment, is required. Work badly arranged or poorly executed will not be *approved*."

One of the easiest rules to comply with and yet it was violated 384 times. Obviously, many—most—of the violations were the result of utter carelessness. Very few, if any, were at all excusable.

The rule next in order, in point of number of violations, was rule 601, section B. This rule was violated no less than 162 times! Section B has to do simply with the maximum allowable current carrying capacities of conductors and a complete table of the allowable current carrying capacities of all gauges of conductors, with various approved types of installations, is given in the rule book. In a sense, these violations were even less to be expected than those of Rule 203. The inability to select the proper size of conductor must be due to nothing more or less than inability to calculate load. When the load is known the correct size of conductor can easily be found by consulting the table in Rule 601. Some of the defect slips were issued because conductors with unapproved insulation or insulation not suitable for the particular job, were used.

Section A of Rule 512 was violated 93 times. According to this Rule: "In kitchens, basements, bathrooms,

lavatories, etc., and in any *damp place*, the external parts of electric fittings and fixtures shall be made of *insulating* material, unless they are out of reach or are *permanently and effectually grounded*. In such places drop lights shall not be used; sockets shall be keyless and shall be controlled by wall switches."

Defect slips were also called for 93 times in the case of Section A of Rule 202, which provides that: "*Electrical equipment* shall be so installed and guarded that adequate provision is made for the safety of persons and property and that it is itself adequately protected from mechanical or other injury wherever it is likely to be exposed thereto." In other words, the work was done in an unsafe manner.

There were 81 violations of Section B of Rule 904. This rule comes under Section 9 of the Canadian Electrical Code relating to grounding. The part (Section B) reads: "*Metal raceways*, metal sheathing and metal armouring of cable, and also outlet and junction boxes on non-metallic *underfloor raceway* systems." This means, of course, that the metallic fittings and other materials referred to must be permanently and effectually grounded.

Next in order, we have Section D of Rule 601 of which 69 violations were reported by the inspectors.

Section D reads: "Joints or splices, unless made with solderless connectors, shall be soldered, but shall first be made both mechanically and electrically secure. All joints or splices shall be covered with an *insulation* equivalent to that on the conductors joined. Ends of *insulated conductors* (e.g., those at switch and fixture *outlets*), if not in use shall be *insulated* as required for joints." Here is another rule, the violation of which seems absolutely inexcusable. Perhaps it is unfair to say that the violations reported were deliberate. And yet it is known silly tricks have been resorted to. For example, the writer recalls seeing an experienced journeyman turn a torch on a joist behind a joint that he had evidently forgotten to solder and had already taped, in the hope that the inspector, seeing the scorched joist, would think the torch had been held to the joint while it was being soldered. While the man was going through all this procedure he could have removed the tape, soldered the joint and re-taped it.

Referring again to the list of violations we find that 69 were reported for Rule 210, Section D. This rule reads: "The following devices, in sizes rated at 30 amperes or less, any terminals or leads of which are intended to be connected to a *grounded conductor* or to the neutral *conductor* of a three-wire d.c. or single-phase a.c. circuit, shall have such terminals or leads identified, unless the fact that they are intended for connection to such a *conductor* is otherwise clearly evident: (1) cut-outs (multipole); (2) polarized receptacles and plugs; (3) sockets (including all lamp-holding receptacles).

Section G of Rule 605 was violated 63 times. Section G requires that: "Holes and outer walls through which *conduit* or duct passes shall be made water-tight in a permanent

VIOLATION OF THE CANADIAN ELECTRICAL CODE REPORTED IN TORONTO DISTRICTS—JULY 1 TO 31, 1932.

Rule	Section	Times Violated	Rule	Section	Times Violated
202	A	93	602	B	19
203	A	9	603	C	17
	B	3		F	16
	C	1	605	A	6
	D	1		G	63
	E	384		I	12
	F	12	801	B	6
204	A	21	802	A	12
205	A	3		B	51
	B	9		C	15
210	D	69		E	6
401	I	9		J	15
402	A	7	809	A	3
	B	9	902	A	39
	D	7	904	B	81
403	A	27		C	3
404	A	3	907	A	30
405	A	12	908	A	9
	B	9		D	12
503	A	3		G	8
	D	7		H	3
	F	3		M	10
504	B	12	909	A	6
505	B	54	910	A	32
507	A	3		D	7
509	D	3	2010	B	6
511	B	12		C	3
512	A	93		D	6
	B	9	2011	F	9
513	D	6		M	2
	F	14		D	1
515	A	9	2012	B	6
601	B	162		E	4
	D	69		I	3
	E	18	2013	B	5
	F	4			

and effective manner, and the openings in such *conduit* or duct, if underground, shall be made *gas-tight* if this be required by the *Inspection Department*."

We also find that there were 54 violations of Rule 505, Section B, under which it is required that: "Bushings of *insulating* material, or other equivalent *approved* means,

shall be provided at all points where *conductors* issue from the armour, to prevent the *insulation* from being injured by the armour."

There were 51 violations of Rule 802, Section B, referring to the mounting of cutouts, as follows: "*Cutouts* shall, except where they are inherent parts of a *switchboard*, and accessible only to *authorized* or *qualified* persons be enclosed in *cabinets* mounted vertically."

There were, of course, many other violations reported of a lesser degree. They are indicated in the table of violations shown with this article.

The above is certainly not intended as a reflection on the electrical workers of the Toronto area. As a matter of fact, similar conditions probably prevail in most sections. Most, if not all, of these violations however, could have been avoided by doing the work in a conscientious, workman-like manner and by refering to the Rule Book as required. One may, perhaps, be excused for forgetting a certain rule, but there is no excuse for failure to examine the Rule Book and learn just what the Canadian Electrical Code requirements are.

It is suggested that all electrical contractors and electricians examine the list of violations and compare it with a list of their own, for, at the present time, an average of two and one-half inspections are required for each permit issued which appears to be far higher than is warranted.

Efforts to reduce the number of defects are bound to have a desired effect and result, in the final analysis, in better work and lower costs.

—*Electrical News and Engineering.*

Super-Conductivity

ON the evening of January 16, 1932, Prof. J. C. McLennan of the University of Toronto gave a demonstration and lecture before the Royal Canadian Institute, Toronto, on his experiments regarding electrical conductivity of metals at low temperatures. Although newspapers made reference to this lecture at the time, it was not until after Prof. McLennan had repeated his demonstration before the Royal Institution in London, England on June 3rd that there was any published description of this work. These descriptions appeared in a number of British technical journals, one of which taken from *Engineering* is reproduced in the following.

At the meeting of the Royal Institution on June 3, Professor J. C. M'Lennan, F.R.S., delivered a lecture on the "Electrical Conductivity of Metals at the Lowest Temperatures."

It was now, he said, 133 years since Day and Faraday, working in the Royal Institution, liquefied chlorine. This was an epoch-making experiment, and led to a succession of others in which one gas after another was liquefied in that laboratory, which thus became world-famous for work of this kind. It had, moreover, an important bearing on the problem of the passage of electricity through metals, which for 150 years had defied solution either

by the experimentalist or the mathematician. Possibly the key to this would be found when we understood of how it was that the conductivity metals was increased by cooling them.

Experiments by Dewar and Fleming in which metals were cooled down to very low temperatures by means of liquefied gases seemed to suggest that the resistance would vanish at the absolute zero. In these experiments the cooling agents were liquefied air and liquefied hydrogen, and with these no very close approach to the absolute zero was possible. In 1908, however, helium was liquefied in Holland by Kammerling-Omnes, and using this agent he, later on, repeated the experiments of Dewar and Fleming, expecting to get very similar results. It turned out, however, that mercury behaved quite differently to anticipation and that at a temperature of about 4 deg. K. its resistance vanished completely and abruptly. This observation, made in 1911, was of prime importance in the study of metallic conductivity and was the most outstanding result of the liquefaction of helium. Of the other metals tried, lead, tin, indium, gallium, thallium, tantalum, titanium and niobium also became super - conductive at very low temperature, the transition points being as follows:—

	Deg. K.
Mercury	4.2
Lead	7.2
Tin	3.72
Tantalum	4.5
Thallium	2.39
Indium	3.4
Gallium	1.07
Niobium	8.2

When cooled down to a certain transition temperature, the resistance of all these metals vanished suddenly and completely, the change taking place within a range of a few tenths of a degree. On the other hand, other metals, such as cadmium, showed no sign of super-conductivity. Their resistance diminished progressively as the temperature was lowered, but never vanished. Nevertheless, some physicists took the view that if the temperature could be got down near enough to 0 deg. K. all would drop their resistance.

In view, however, of experiments made years ago, the speaker did not feel quite convinced that this would be the case. The Heussler alloy, which consisted of manganese, aluminium and copper, was about as magnetic as cast-iron, though all its constituents taken individually were non-magnetic. Reasoning from analogy it seems to him that quite possibly some alloy might prove to be more super-conductive than its constituents and have a higher transition temperature. This surmise was proved to be correct when Kammerling-Omnes showed that an alloy consisting of gold and bismuth in certain proportions was super-conductive, though neither of the constituent metals showed a trace of super-conductivity. Thanks to the ability of his assistant, Mr. Flim, the speaker in his own laboratory was able to attain a temperature of 1 deg. K., and determined to investigate a series of alloys. A highly exaggerated account of some of his work had appeared in the daily press, which credited him with having discovered

an alloy super-conductive at room temperature, but actually the highest transition temperature he had yet recorded was one of 10.5 deg. K., which was that of niobium carbide, and from that to room temperature was a very long way.

Some very interesting results had been obtained with alloys of metals belonging to the bismuth group. Still more remarkable, however, was the discovery at Leiden that copper sulphide became super-conductive at low temperatures, although sulphur was one of the best insulators known, and copper showed no trace of the phenomenon at the lowest temperatures reached. Following up this, the speaker had found that the compounds SnAs and PbS were both super-conductive, as also the carbides of tantalum and niobium. The transition temperature of the latter was 10.5 deg. K., the highest yet found, whilst that of pure niobium was 8.2 deg. K. In experimenting on ruthenium one sample was found to be super-conductive, whilst others were not. The explanation was found to be that the atomic hydrogen blow pipe was used for melting the metal. The hydrogen on its way to the jet was passed through a tungsten arc, and had, it turned out, carried over with it some tungsten which was deposited as a film on the ruthenium. Titanium nitride and some other nitrides also proved to be super-conductive.

At this point the lecturer exhibited a small ring of lead which had been rendered super-conductive at Leiden that morning by immersion in liquid helium and a current of several amperes started in it. Thanks to the assistance of the Master of Sempill, this, protected by triple Dewar flasks, had been brought over from Holland by aeroplane in two and a half hours, and, as the lecturer showed, the current was still unidiminished and would, he said, continue unabated until the helium had evaporated off. It had, the speaker said, been found impossible to detect, using the most delicate instruments, any diminution in such a current even after the lapse of thirteen hours. This was a property of profound importance of which as yet there was no mathematical explanation.

Returning to his experiments on compounds, he said that, though Ag_3Sn was not super-conductive, a eutetic of this compound and tin was. Other eutetics also proved to be more super-conductive than compounds and than simple metals. This was a new fact.

The effect of stretching wires whilst in the super-conductive state had also been examined, and was found to raise the transition temperature. Magnetism on the other hand, lowered the transition temperature and destroyed super - conductivity. It was, in fact, the effect of its magnetic field which limited the current which could be passed through a super-conducting wire. In the case of a lead-bismuth alloy at 1.2 deg. K., a field of 20,000 gauss was required to establish a resistance, whilst with metallic thallium 15,000 gauss sufficed.

The contraction of metals with cold showed no anomalies. A super-conducting metal contracted steadily as the temperature was lowered. Moreover, if a metal were in the super-

conductive state and this was destroyed by applying a magnetic field, there was no accompanying change in the length of the wire. Apparently the total resistance of a metal was due to two terms, only one of which was due to the thermal agitation. In the super-conductive state all metals acted alike.

The current through a metal was generally supposed to be carried by electrons, and the β-rays emitted from radium were high-speed electrons. It appeared of interest, therefore, to find whether, in the super-conducting state, these rays passed more easily through a plate of lead than when the lead was at room temperature. It turned out that there was not the slightest difference. This was a disappointing result, but was apparently due to the fact that, as Professor G. P. Thomson had shown, electrons had a wave aspect, and the frequency of the waves was inversely proportional to the speed. In the case of the β-rays the associated frequency was 10^{21} vibrations per second, and with this periodicity lead was not super-conductive at the lowest temperatures attainable. In some further experiments the electrons used were obtained from a photo-electric cell, the associated frequency being 10^{14} vibrations per second. Here again the absorption of the lead was identically the same at all temperatures. In further work mirrors of lead deposited in an atmosphere of argon were used. These were so thin that ordinary light passed through them, but they were opaque to electrons having an associated frequency of 10^{14}.

The next step was to apply alternating currents having a frequency of about 10^7 per second. With these lead proved to have still a resistance at 7.2 deg. K., which is its normal transition-point, but it became super-conductive when further cooled to 5 deg. K. Other experiments on tin and thallium gave corresponding results, and the higher the frequency the lower became the transition temperature; and the conclusion reached was that at 0 deg. K. there would be no sign of super-conductivity if the frequency of the current was 10^9.

The effect was independent of the strength of the current, and was thus not due to a heating effect or to the magnetic field, whilst that it was not a skin effect was proved by using wires of different diameters. It was concluded, accordingly, that it was a function of the frequency only, and that polarization and orientation phenomena were involved in the produc- of super-conductivity, this electrical state being somewhat similar to the saturated magnetic state obtainable with ferro-magnetic metals.

THE
BULLETIN

Published by
HYDRO-ELECTRIC POWER COMMISSION
of Ontario

190 University Ave.
Toronto

Subscription Price $2.00
Per Year

Chairman, the Honourable J. R. Cooke's Address to the Canadian Club

(At Toronto, November 7, 1932.)

MR. President and gentlemen, I hope in the introduction your President has given that you will forget, for the moment at least, that I have been associated for 21 years with some of these gentlemen surrounding me. It is now over a quarter of a century ago since the Legislature of this province realized that, situated as we are in a province without coal, our industrial operations must largely depend on the development of our water-powers, and so the Hydro-Electric Power Commission was formed with authority to deal with those problems. It is many years ago since those most active in the affairs of the Hydro-Electric Power Commission recognized that if the Province would realize to the full the possibilities that its water-powers offered, it could only be by developing them under some large comprehensive scheme by which industry would be assured of abundant reserves of power at the actual cost of power production. And so this province embarked upon a scheme by which the Province itself financed the Power Commission in the development and transmission of power, and, contrary to the general impression that has existed, that the municipalities have pledged bonds or debentures for the service which the Hydro Power Commission renders, there is not a Hydro municipality in Ontario that has ever pledged one dollar of negotiable securities for the investment that has been made by the Hydro Power Commission. The whole operations of the Commission are upon the credit of the State itself because of the $270,000,000 which the Power Commission has invested in those services $200,000,000 have been advanced by the Province in cash and the balance has been financed by Commission bonds guaranteed by the Province of Ontario.

The Commission in its operations has divided old Ontario into four distinct systems, each of which is a single unit, and the expenditures made by the Commission in any one of those systems is in no way reflected in the cost of power upon any of the

CONTENTS

Vol. XIX No. 11
November, 1932

other systems. The area which lies between Whitby on the west and the Ottawa River is what is known as the Eastern Ontario system. Then between the County of York in the east and Windsor on the west and Niagara Falls on the south lies the Niagara and most important system. The Georgian Bay system serves that territory from the northern boundary of the Niagara district and embraces Bruce and the other counties of north-west Ontario. Then there is the Thunder Bay system which serves Port Arthur and Fort William.

The underlying principle of all the Commission's operations is that power must be supplied to the municipalities at cost. It was upon that principle of power at cost that $360,000,000 have been invested by the Province and the municipalities in their operations, and so any departure from that principle at present would be quite unthinkable. Now the method by which the Commission has been financing all its operations is, as I have said, either by direct advances in cash by the Province of Ontario or else by a bond of the Commission that is guaranteed by the Province. I don't know that I can explain it to you more fully.

Your President has just suggested to me to say something upon the controversy in regard to exchange. When you realize that 43 per cent. of the total capital indebtedness of the Province of Ontario is the cash advances that the Province has made to this Commission, then you see the importance of the Commission paying the full cost of that money to the Province. The Province of Ontario does not make one dollar through advancing money to the Commission. What the Commission pays to the Province for these cash advances is the average cost of money to the Province of Ontario for that year. The average cost of money over many years was around five per cent. But the cost of money is the most important factor in determining power costs to the municipalities.

Briefly sketching the method by which the municipal power costs are arrived at I might suggest this to your mind. In basing the rates which each municipality must pay to the Power Commission for power, it takes into consideration the amount of revenue that is necessary in order to pay the interest, which to date has been about 5.1 per cent., and secondly the amount of revenue that is necessary to form a sinking fund to redeem the bonds of the Commission and to repay the cash advances to the province over a forty-year period. That is about 1 per cent. The next most important factor is to secure sufficient revenue to set up a renewal reserve sufficient to maintain its

property at 100 per cent. efficiency, so at the end of the sinking fund period, or when the ownership of these properties passes to the municipalities, they will either be in perfect state of operation or else there will be sufficient money on hand to rebuild them. Then there is a fund to be set up for stabilization of power costs and contingencies. The Commission also has to secure sufficient revenue to pay over to the Province rentals upon the power sites that it is developing. It has to secure sufficient revenue to pay the amount of municipal taxation levied on the properties which the Power Commission operates. And then there is operating and administrative charges.

Now all these factors together amount to about ten per cent. upon the amount of investment made by the Commission to provide for that service. Let me illustrate perhaps more clearly how it works out. Let us suppose that municipality "A", located in the Niagara system, applies to the Commission for 10,000 horsepower and the Commission finds that it is necessary for an investment to be made of $2,000,000. Then 10 per cent. upon that $2,000,000, or $200,000 is the annual charge made to Municipality "A" for that power or $20 a horsepower. But let us suppose that municipality "B", located in the eastern system, applies for 10,000 horsepower and the Commission finds that owing to the development being more costly, or the transmission distance being greater, that it is necessary to make an investment of $3,000,000 to give them that service. then 10 per cent. upon that $3,000,000 or $300,000 will form the annual charge to municipality "B", or $30 a horsepower.

But in that set up of the factors that determine the power costs to the municipalities you will notice that the dominating factor, the costs of money, are over 60 per cent. of the total power costs. The interest charge which the Commission has to pay to the Government of Ontario for this year is roughly speaking quite a bit in excess of $10,000,000. The amount of interest that the Commission has to provide for, upon the bonds which have been assumed or given by the Commission in the purchase of different power plants is around $2,400,000, plus the sinking fund which the Commission has paid over to the Province for its cash advances, is this year,—and I am speaking just approximately—60 per cent. of the total power costs.

Now the cost of the exchange is just as much a part of the cost of money as the interest was. To-day that amounts to about six-tenths of one per cent., and yet your regular interest rate plus the exchange is less than the amount of interest which the commission paid in 1919.

That sketches briefly the method by which the Commission determines the costs that it shall charge the municipalities for power. But when the municipalities attempt to merchandise or retail that power to their customers, again the Commission must approve of the rates that will apply for the different services, such as domestic, commercial or municipal, and for this reason, because that municipality had found it necessary to issue its own debentures to either purchase or construct its own local

distributing system, and the Commission is anxious to see the revenue secured by the local commission will be sufficient not only to pay for the wholesale cost of power to the Commission, not only pay operating and administrative charges, but that it will be also sufficient to redeem the debentures which that municipality had issued in order to provide the distributing system, so that there shall never be one dollar of municipal taxation imposed on property in any form for electrical service by the Hydro Power Commission.

There was no security ever pledged by the municipalities for the payment of these tremendous advances of the Province, but I have always believed that there were two things in legislation that gave great protection for the repayment of those advances. First there was the authority which the Legislature gave to the Government years ago to dictate the personnel of the Commission, whose duty it would be to see that the affairs of the Commission were kept in such a solvent condition that there would never be any question of its ability to repay these huge advances by the Government of Ontario. The second thing was, as I say, that the Legislature gave authority to the Commission to dictate the rates, and it is very seldom that any friction has ever arisen between the municipalities and the Power Commission upon that score.

Now the methods employed by the Commission in dealing with rural distribution is somewhat different from those of dealing with urban centres, because, while the Commission compels urban municipalities to issue their own bonds or debentures or to purchase or construct their own distributing systems, the Commission does not ask the power customer in rural districts to invest one dollar or one cent. The Commission, through cash advances made by the Province of Ontario, makes every dollar of investment that is necessary to take the power to the farmer's home, even to purchasing the transformers that are necessary. Not only that but, while the commission compels the urban municipality to repay with interest every dollar that the province has advanced to give them service, the commission only asks for a return from the rural customer of one-half of the money invested for their service, making the rural customer a free gift of one-half of the money that was invested for their service.

Now the reasons that prompted the Legislature to adopt the principle to bonus the construction of highways throughout Ontario and to give a greater legislative grant to rural schools than they do to urban schools are the very reasons that prompted the legislature, a few years ago, to give a grant in aid to rural distribution. I think it is generally conceded by everybody, particularly at this period, that one of the great evils of the day is the drift of population from the country to the city, and I was much interested in the remark made by one of the speakers at the Canadian National Exhibition a few years ago, when he said that a more serious effort should be made to readjust the balance of population between the country and the city. But, Mr. President, that drift of population from the country to the city is a

condition that is not peculiar to the Province of Ontario alone: it is a condition that is common to practically every state of the great American Republic to the south of us. Dr. W. J. Black, in giving his evidence before the parliamentary committee upon colonization and immigration at Ottawa, made this significant statement in his evidence. He said there is going on in the British Isles to-day a movement that is going on in every country that is a joint agricultural and industrial country, and that is a movement from the country to the city. He said that he had lived in England during the previous year and was closely in contact with what was happening and that in that year over 60,000 men had left the farms of England and gone to the towns and the villages to live. So that drift of population, I say, is general wherever the Anglo-Saxon race is dominant in any country, because the Anglo-Saxon race for the past few years has been seeking the secret of acquiring higher standards of living. What is the great difficulty in dealing with the problem? In cities you see wealth, assessable wealth, largely assembled upon a small area, and statistics show that the average assessable value of the town and city is about $5,000,000 a square mile. In the city, I believe, it approaches more closely perhaps to twenty-five. But the average for Ontario is about $5,000,000, while the average assessable value of farm lands in this province is less than $50,000 a mile. Now, owing to the fact that assessable wealth is 100 times greater in the city than it is upon the same area in the country, one can easily understand the unbearable rate of taxation that would be necessary in the country to provide the same luxuries and the same conveniences that every living human being, who seeks to earn an honourable living, is entitled to enjoy. If you want to retain upon the farms of this province our own Ontario born population, who are the most valuable to our agricultural life to-day, then generous assistance must be given by the Legislature of this province, not only in the construction of highways, not only in the elementary schools of Ontario, but generous assistance must be given by the Legislature towards the distribution of electric light and power in the rural districts; so that you may in some way help to lighten the burden, so that you may in some way help to brighten the lives of those who are far removed from the many conveniences and the splendid educational institutions of our towns and our cities. Those who in the solitude of the isolated farm home are doing the work that is necessary for the common progress and prosperity of this country.

It was with these thoughts in mind that the Legislature of Ontario in 1923 paid the first bonus for rural construction. That first payment was for $425,000 and in the following year, in 1924, that legislation was amended to practically double the legislative assistance. The result was that it so stimulated rural demands that, while previous to 1924 there was less than 800 miles of rural lines in the Province of Ontario, in the eight year period that has since elapsed the Power Commission has been building an average of three miles of rural lines every work day in the year, with the

result that there are to-day over 8,000 miles of rural lines in the country serving over 60,000 rural customers.

The effect of that legislation has been this, that, while previous to that period the service charge alone to the rural customer was about $7 a month, in 1930 the Legislature again passed legislation which authorizes the commission to make a maximum service charge of $2.50 and the Province of Ontario out of its revenues takes care of whatever deficit would be incurred. That means that the service charge in the 8 years has been decreased by 65 per cent.

The Province of Ontario has handed over to the Power Commission for that purpose almost $16,000,000, so that the rural power customer finds to-day this remarkable situation, that in that 8 or 9 years he actually owns an interest in that $16,000,000 of about 65 per cent.

Now turn to the other questions that your President has suggested; that is purchase of power and matters that have been under controversy. He has suggested the Dominion Power and Transmission, but that has been dealt with so completely that I think it is clearly answered. I might say this of course; you understand from information which has been given out from time to time by the Power Commission that it had in mind the thought that the real value of these properties to the Commission lies in the fact that in the not distant future it would be developing there 200,000 horsepower with a peak power proposition instead of 50,000 or 60,000 h.p. as it is to-day.

But entirely aside from that, the Commission took over those properties on the 1st of January, 1930. It has not yet had a report from the auditors for the present year. But for the first 22 months of operation, from January 1, 1930, to the end of October, 1931, the report of the auditors disclosed—but perhaps I might point out the amount that was paid for the property. The Commission in purchasing this gave $8,000,000 of 5 year, 4½ per cent. bonds and $13,000,000 of 5 per cent. bonds. Now the reason for that was it believed that it would be able in the five-year term of the bond to dispose of certain extraneous properties outside of the power properties. But the result of our operations for the 22 months disclosed that out of the earnings of the system it has paid the full interest charges upon the full $21,000,000. It paid all operating and administration charges and taxes. It set aside $100,000 for depreciation, and it still had $52,000 of surplus. The report of the auditors and the engineers was to the effect that after it had sold certain of these properties and revamped the power plant, the Commission would be able to have power in that area at, I think, a cost of $11.50. There is no possible way in the world that it could deliver power from the Queenston development at anywhere near that price.

Now turning to some of the contracts entered into by the Commission in Quebec, I can only at best sketch the program very briefly, In 1923, when I first came upon this Commission, one of the first problems with which the Commission was dealing was a further supply of power. The Commission made the most exhaustive investigation of the cost of

steam-power with the result it realised, if it could purchase power at a price, say, of $15 that it was infinitely preferable to building a steam plant; and so the Commission began negotiations in the Province of Quebec. While up to that time the Commission had been asked $18, $19 and $20, it finally concluded an agreement with the Gatineau Power Company to deliver 260,000 horsepower at the Ottawa boundary at a price of $15 in 1930.

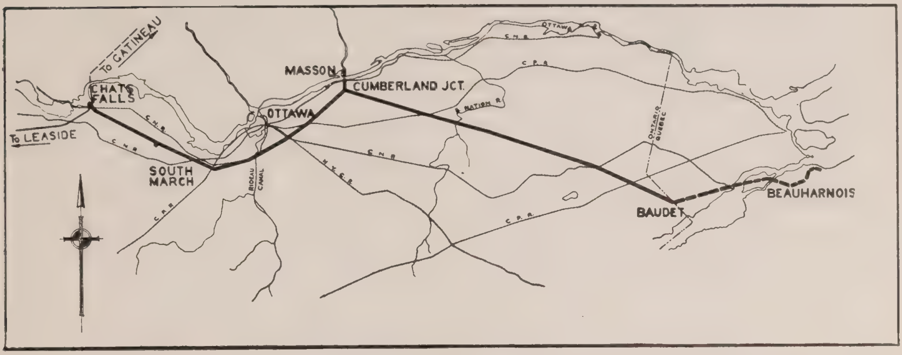
If you will go back and look at the situation, you will find that there are four plants operating at Niagara on the Canadian side. There is the Canadian Niagara Power Company, which is a private corporation developing 100,000 horsepower; there is the Electrical Development Power Co., and the Toronto Power and Electrical Development Co., developing about 120,000 horsepower and the Ontario Power Company, developing 180,000 horsepower, quite inefficient plants in the use of water. The Electrical Development Co., developed only about 10 horsepower per cubic foot second and the Ontario Power Co., about 18 h.p. The Queenston plant develops 30 horsepower per cubic foot second.

Many years ago the technical men of the staff of the Power Commission had the dream of building the Chippewa canal. It required not only vision but courage in that undertaking. When you realize that the men in charge of these affairs, the engineers of the Commission, are Canadian born, that they have been trained in the elementary schools and the Universities of this province, and have made such a tremendous success of this wonderful undertaking, it is something of which every Canadian citizen can be proud, that that type of men have been in charge of the technical affairs of the Power Commission, and they are the men who are still in charge to-day. The Commission never enters into any important undertaking without the advice of those technical men. It was found in 1923 that the end of the power resources at Niagara was in sight, and so in 1927 and 1928 after the Commission had made arrangements for the purchase of the Gatineau Power, and believing it was absolutely impossible to secure power from the St. Lawrence before 1938 or 1940, it asked the technical men to prepare a program of what they thought would be the power supplies that would be necessary up to 1937. In June of 1924, the Commission had made application to the Government at Ottawa for authority to develop power upon the St. Lawrence. But up until the beginning of 1932 no progress was made. Since that time negotiations have been going on, as you well know, between the United States and Canada and, subject to ratification of that treaty by the United States, the Province of Ontario has entered into an agreement with the Federal Government for power upon the St. Lawrence River. You hear such sums spoken of as $115,000,000 and $120,000,000, but that doesn't give you a clear picture of the reality. The Commission had arranged, I say, to purchase power supplies to carry it over the period until 1937. Now there is not any question that owing to this depression the provisions the Commission has made for power

will perhaps carry it further along than 1937 but there is no other commitment made by the Commission for any other power. I believe the Province of Ontario has negotiated an agreement with the Federal Government, whereby certain things that have been in dispute over a long period of years, for instance ownership of the water-powers of the St. Lawrence will, under the terms of the agreement, be ceded to the Province of Ontario. But the Province of Ontario does not have to make one dollar of that payment until 1942, when out of the total amount involved the Province will then have to pay $28,000,000, that is, ten years from now. Then in the period between 1942 and 1945 the province must pay another $39,000,000, and in the period which elapses from 1945 to 1952 the balance of the money is to be paid. So you can see what little risk the Province of Ontario is taking and what little provision has to be made for financing in the next 20 years.

In 1930 it was found that the power loads of the Commission were such that it was using every unit of power available at Niagara Falls and practically every bit of power secured from the Gatineau power contract. It has since then made commitments, not for the 800,000 or 900,000 horsepower you read of in the press, but for 470,000 horsepower, that is 250,000 from the Beauharnois, 125,000 from the MacLaren on the Lièvre River, and 96,000 horsepower at Chats Falls, or 471,000 horsepower. That is to carry the Province over the intervening period which lies between now and 1937. Only 35,000 horsepower was taken from the Beauharnois this year and it goes on in annual increment for the next five years. It is the same with the MacLaren Co. The Commission won't take delivery of any power until 1933. When people talk about the commitments of the Commission totalling ten millions a year, they do not realize that is to take care of the growth of power loads in Ontario until 1937.

Chats Falls-Beauharnois 220 kv. Extension



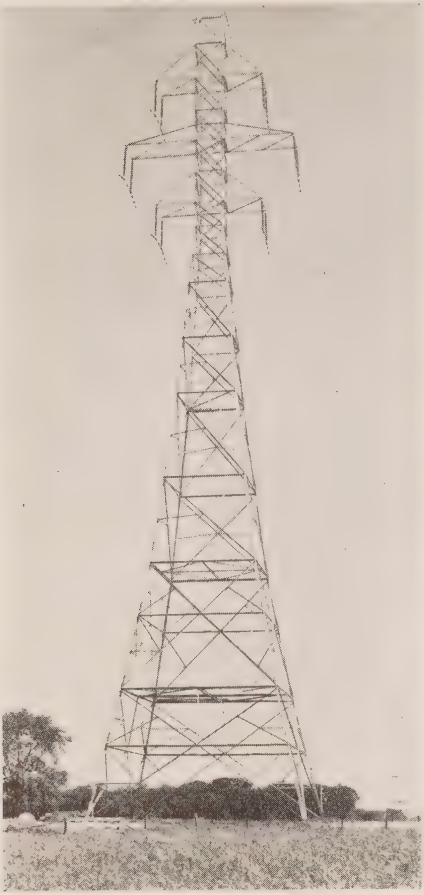
Map showing location of "Beauchats" lines which connect the Beauharnois (St. Lawrence) and MacLaren (Lièvre) Development in Quebec with existing 220 kv. system at Chats Falls in Ontario.

On October 20, 1932, the 220-kv. single circuit steel tower line which had been constructed during the summer to deliver the power purchased from the Beauharnois Co., to the existing 220 kv. system was placed in service. This line extended from a point on the Ontario-Quebec border, near Baudet, to Chats Falls.

The Ontario portion of this line is slightly over 100 miles in length; the extension into Quebec, which is controlled by the Beauharnois organization is slightly over 25 miles in length. (The Beauharnois works are described in the October number of this publication).

In the vicinity of the village of Cumberland, east of the city of Ottawa, provision is made for a tap and for a crossing over the Ottawa river so as to connect in the power development on the Lièvre river when

220 kv. lines Gatineau and "Beauchats" crossing one another in the vicinity of Chats Falls.



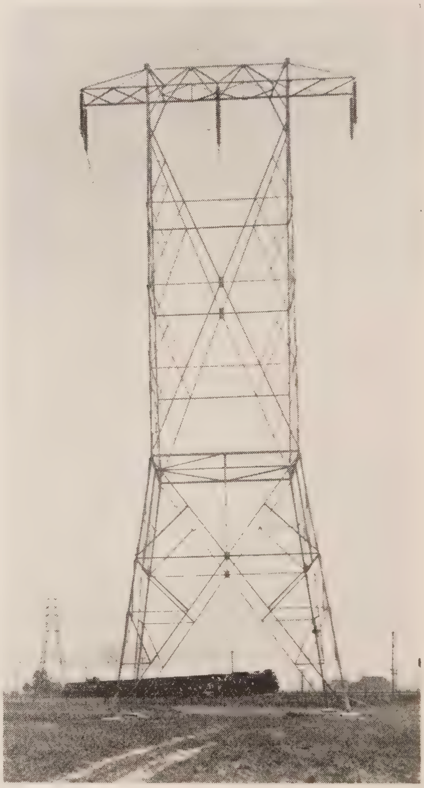
Special 220 kv. structure (double circuit) over St. Lawrence River and Soulanges Canal in Quebec (B. H. L. & P. Co.).

required. This will add 3.2 miles to the length of the line. The result will be that 128½ miles of line will presently be connected to the 220 kv. system east and south of Chats Falls.

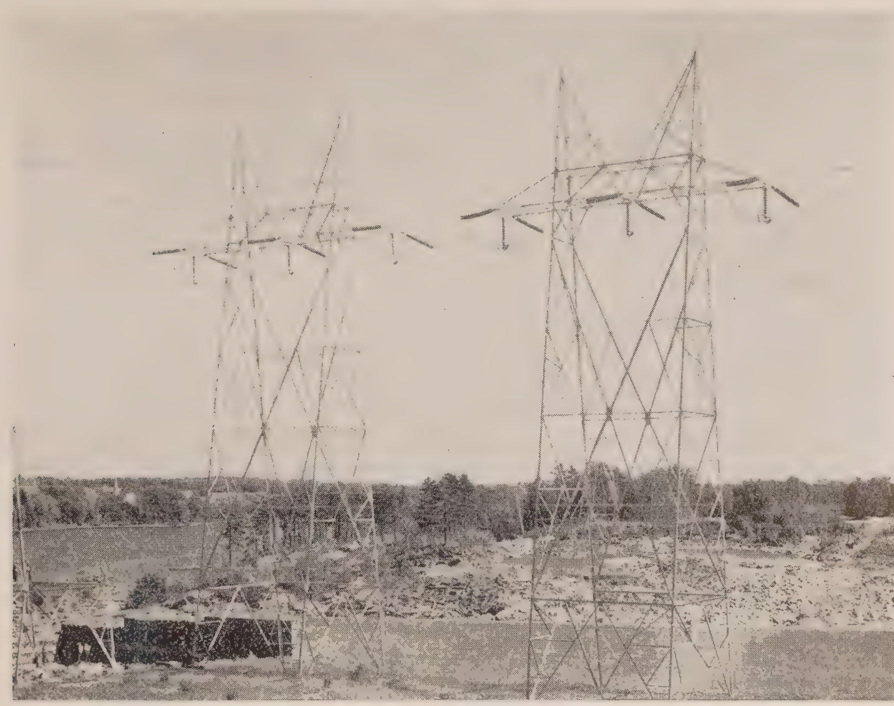
The contract between the Commission and Beauharnois provides for a total of 250,000 h.p. The first block of 35,000 h.p., is being made available in the fall of 1932. The contract increases by annual increments until the final amount is to be taken about the year 1936.

From the map, it will be seen that this line extends easterly from Chats Falls, where it crosses two of the existing Gatineau-Leaside lines. It runs generally south-easterly until it reaches the Rideau river opposite Ottawa at a point sufficiently removed to eliminate urban complications. From this point it turns slightly north and east so as to be near the Ottawa river opposite the Lièvre development, thence it is carried in practically a direct line south-easterly to a point on the Ontario-Quebec boundary, near Baudet.

This line is generally similar to the



Beauharnois Company portion showing crossing of main line of C.N.R. near Coteau, Quebec.



Specially constructed towers with elevated (25 feet) ground wires and "spillway" gaps on suspension insulators. Rings are used only in the vicinity of stations.

earlier 220 kv. construction by the Hydro. Some of the minor charges have reference to the way the ground wires are attached to the structure, and to separating them so as to provide greater electrical protection. An attempt was made to more satisfactorily reinforce conductors and ground wires at all clamps.

For a short distance outside of Chats Falls station, some special construction has been introduced. The vertical spacing between power conductors and ground conductors above has been nearly doubled as compared with the standard construction. It is intended that this shall afford greater protection to the electrical works in the vicinity.

Wherever possible the material in the ground wire equipment has been made of a material as pliable and ductile as could be supplied and still conform to the mechanical requirements.

Construction work on this line in Ontario was commenced on May 3rd, 1932, surveys having been undertaken about one month earlier. The work was carried out by the Construction forces of the H.E.P.C. There is no telephone.—*A.E.D.*

Correction—

The date on which Beauharnois power was received as shown on page 319 of the October *Bulletin* should have been stated as October 20, 1932.

Hydro-Electric Power Development in Canada

By T. H. Hogg, D. Eng., Chief Hydraulic Engineer, H.E.P.C. of Ont.

(Presented at the Semi-Annual Meeting of The American Society of Mechanical Engineers, Bigwin Inn, Muskoka, June 27th to July 1st, 1932.)

IT is proposed, in this paper, to discuss the present status of hydro-electric power development in Canada, to outline the attitude toward governmental supervision and control in various parts of the country, and to describe briefly some of the outstanding features of recent large developments.

STATISTICAL

Large additions to the country's turbine installations came into service during the past year, and the current year will see further increases. New developments in 1931 account for a net gain in turbine installation of 540,000 h.p., a figure only twice exceeded in other years, and the total development amounted to 6,666,000 h.p. at the end of that year. This figure has been reached by a more or less steady growth since the beginning of the century, somewhat accelerated in recent years, and, while paralleled by similar growth in other countries, represents a larger per capita development than exists in any other country except Norway. The growth of development in Canada is shown in Fig. 1. It is interesting to note that in 1900 the total development amounted to less than 200,000 h.p., had grown to 1,000,000 h.p. in 1910, to 2,500,000 in 1920, and at the present time is twice as great as it was in 1924. This total is made up of 2,700,000 h.p. in Quebec, 2,100,000 h.p. in Ontario, 600,000 h.p. in British Columbia, over 300,000 in Manitoba, and the remainder in the other five provinces.

At the risk of repetition, attention must be drawn to those conditions which have promoted intense hydro-electric development in the central portion of the country. The provinces of Ontario and Quebec are devoid of coal deposits and therefore dependent for their fuel supplies upon importation from the states immediately south of the international boundary,

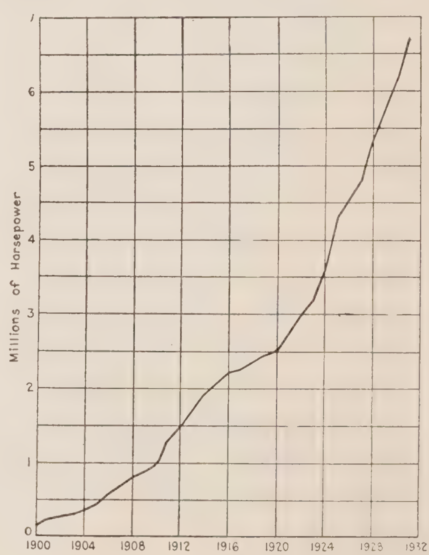


Fig. 1.—Growth of Water-power Development in Canada.

or upon the mines of Nova Scotia in the extreme East, or of Alberta in the West. The costly long rail haul from either of these domestic sources has resulted naturally in the bulk of coal supplies for the central provinces being drawn from Pennsylvania, Ohio, and West Virginia. When transportation charges from these relatively nearby sources are added, the cost of energy produced from the fuel becomes a serious burden on industry.

Canada is considered generally to depend mainly on its agricultural products. Its manufactured products, however, have a gross value almost twice as great as its agricultural products, and greater than the total value of products of all primary industries (agriculture, forestry, mining, fisheries, etc.). In 1928 the gross value of products manufactured in Canada amounted to $3,769,850,364, and 80 per cent. of these products came from Quebec and Ontario. Thus these provinces, in spite of their lack of fuel supplies, are the principal seat of industries in which in most countries fuel is one of the essential raw materials. This preeminence is explained in part by the availability of hydraulic power, and on the other hand explains the very extensive development of hydro-electric energy in this area.

Increasing demands for electric power supplies are not accounted for only by greater demands in industry. In the commercial and domestic fields, as well as in industry, new adaptations are responsible for appreciable growth and, while business conditions during 1931 led to a reduction in power demand, it is not unreasonable to believe that a return to normal business conditions will be followed by absorption of all supplies now developed and under construction, and even increased demands on account of these new adaptations.

Physical Conditions Promoting Development

This extensive development of hydraulic power has been promoted, as has been indicated above, by large demands for industrial, commercial, and domestic power in a district devoid of fuel supplies. Physical conditions, however, must be such that the potentiality of the streams can meet the demands.

The maximum elevation in Ontario is only slightly above 2,000 ft., and in Quebec the mountain ranges lack by far the extent and altitude of the ranges in the Atlantic states or the western part of the continent. Developed heads are therefore moderate, relatively few exceeding 200 ft. Wide distribution of available sites compensates for lack of greater concentrations of head.

Stream-flow regimen differs materially from that existing in rivers elsewhere on the continent on which large developments exist. Precipitation in Ontario and Quebec is less than in the region to the south of the Great Lakes, and decreases somewhat as one proceeds northward. The distribution throughout the year is fairly uniform, but heaviest in the winter months as one approaches the seaboard, and in the summer months toward the northwest. Intense precipitation resulting in high flood stages is seldom experienced, and, in general, the ratio of low to average flow is high. Innumerable lakes of all sizes, widely

distributed, serve to further improve the natural distribution of the run-off, and in some instances artificial control of lake expanses has effected practically perfect regulation of the rivers. The natural regulating effect of the lakes probably plays a greater part than any other single factor in making the rivers of the central provinces such important power sources.

Specific examples of natural regulation may be of interest. Reference need only be made to the St. Lawrence to draw attention to the possibilities of natural lake regulation. Here the maximum flow at the outlet of Lake Ontario during the past 70 years was only twice as great as the minimum. This, of course, is very exceptional. The Ottawa River, however, is more typical of streams in the district. At Chats Falls this river drains an area of 34,000 square miles, has an average flow of 45,000 cu. ft. per sec., and minimum and maximum flows of 12,000 and 220,000 cu. ft. per sec., respectively. These results are from records extending over a period of 20 years. A ratio of maximum to minimum flow of less than 20 indicates a natural regulation of a high degree. Artificial regulation of some of the lake expanses on the main stream and tributaries has effected an appreciable improvement over these natural conditions, so that it is not expected that the minimum flow will fall below 22,000 cu. ft. per sec. in the future.

An example of even more striking natural regulation is afforded by the Nipigon River in north-western Ontario. The records are not complete, but extremes of lake stage indicate that the ratio of maximum to minimum outflow has been about four. This river is now completely regulated by the Virgin Falls dam at the lake outlet. The capacity of the storage basin formed thereby is 6,700,000 acre-feet, which is believed to be greater than the capacity of any other regulated storage basin, with the exception of Lake Superior.

The above discussion with respect to stream flow applies to the provinces of Ontario, Quebec, and eastern Manitoba. Eighty-five per cent. of the capacity of hydraulic power developments are located in this area. Developments are very extensive in British Columbia, where heavier precipitation and steeper river slopes provide many attractive sites.

Governmental Control

As with other natural resources, control of water-power development rests with the provinces. Until recently, the Dominion Government controlled power sites and issued development licenses in the western provinces, but the transfer of control of natural resources to the provinces was completed a few years ago.

The nature of the control exercised varies. In four provinces, hydro-electric power commissions operate. In the province of Quebec, the Quebec Streams Commission makes recommendations as to control of water resources, and has constructed and operates storage works on a number of rivers. In British Columbia there is no provision for development except by private agency, but in all provinces, including those in which power commissions exist, provision is made for the issuance of licenses for development by other than governmental agencies.

A brief account of the events that have culminated in the extensive publicly owned system in Ontario will be of interest. It became evident in the early years of the century that hydro-electric development would become a key industry, and interest in this in Ontario was developed by the expanding manufacturing development and the inception of construction work on three large power plants at Niagara Falls. In 1903, seven municipalities united in an investigation of the transmission possibilities of Niagara power and other related subjects, by the appointment of the Ontario Power Commission under enabling legislation passed by the Provincial Parliament. This commission published a comprehensive report in 1906, which resulted in the passage by the Provincial Government of the Act creating the Hydro-Electric Power Commission of Ontario. In 1908, by-laws were passed by thirteen municipalities authorizing their officials to make contracts with the Commission for a supply of electrical power. Transformer stations and transmission lines were built, and power, purchased from the Ontario Power Company, was distributed first in 1910. The initial load of 1,000 h.p. grew quickly, amounting to 100,000 h.p. by 1915, 356,000 h.p. by 1920, and now amounts to over 1,300,000 h.p., generated mainly in plants owned by the Commission.

The basic conception of the whole electrical undertaking controlled by the Commission is that it is a partnership of municipalities formed to obtain power at cost, each municipality paying its share of the cost for the service received. The Commission, acting as agent and trustee for the municipalities, exercises both administrative and constructional functions, and, by application of the principles adopted, has evolved a well-defined working policy for the development, transmission, and distribution of hydro-electric power under municipal ownership.

The partnership now comprises over 550 municipalities, of which about 325 are urban municipalities and 225 are townships. The local distribution of electrical energy within the borders of each municipality is, in general, under the administration of a public-utilities commission appointed by the municipality.

Development of power in Ontario is not wholly in the hands of the Hydro-Electric Power Commission. Provision is made for the issuance of licenses for power rights on rivers to private corporations. One of the large developments now proceeding, which comes in this group. is that of the Ontario Power Service Corporation on the Abitibi River, to which reference is made later. Private enterprise controls plants in the province generating over 1,000,000 h.p., which is used in industrial plants directly, or distributed to consumers through some twenty independent transmission systems.

In Quebec, private enterprise has been looked to for the supply of electrical energy. Active assistance is provided by the Quebec Streams Commission, which "is authorized to ascertain the water resources of the province, to make recommendations regarding their control, and to construct certain storage dams and operate them so as to regulate the

flow of streams." This active assistance has included the systematic collection of data on the flow of streams and meteorological conditions prevailing, the investigation of power sites, the determination of the longitudinal profile of many rivers, and the construction and operation of storage works. The last-named item is probably the one of most effective assistance. Reservoirs have been built by the Commission on the St. Maurice River, where the low-water flow has been increased thereby from 6,000 cu. ft. per sec. to 19,000 cu. ft. per sec., and on the St. Francis, Metis, North, and other rivers. Reservoirs also have been built by interested power companies on the Gatineau, Lièvre, and Mattawin Rivers. These reservoirs are the property of, and are operated by, the Commission.

Three other provinces have hydro-electric power commissions similar in most respects to the Ontario Commission, viz., Nova Scotia, New Brunswick, and Manitoba. In the last-named province also, the city of Winnipeg has its own hydro-electric system, with power developments on the Winnipeg River at Point du Bois and Slave Falls.

The Pulp and Paper Industry

No statement with regard to power development in Canada would be complete without a reference to the amount of power developed for, and used by, the pulp and paper industry. The industry has had a growth paralleling the growth of hydro-electric power. The output of wood pulp in 1910 amounted to 475,000 tons, and in 1929 to 4,021,000 tons. Paper production in the latter year amounted to 3,200,000 tons. Its development has been due to the existence in Canada of abundant water-power resources adjacent to extensive forest resources of pulp-wood species. The power demands of the industry are large, approximately 100 h.p. per ton of daily output of newsprint being required. Continuity of service and low-priced power are essential factors in economic operation.

In many instances, pulp and paper companies generate power for their own use in close proximity to their mills, the pulp and paper industry itself having a total installation of over 600,000 h.p., and additional hydro-electric energy is purchased to operate motor installations aggregating over 990,000 h.p. The total power used in the industry is thus in excess of 1,500,000 h.p., and of this 82 per cent. is hydro-electric. As with other manufacturing industries, the bulk of the production of pulp and paper is in the central provinces. Quebec produces about 56 per cent. of the total, and Ontario, 34 per cent.

Turbines

Reference has already been made to the constancy of flow of the rivers in the central part of the country particularly, and to the fact that developments under moderate heads are in the majority. A third factor, along with these, has had a great influence in determining the type of turbine equipment commonly used, namely, that isolated plants are rare and interconnection between extensive transmission systems is common. Under these conditions most Canadian plants of large size are equipped with

Francis-type turbines of moderate specific speed, or those of the propeller type of high specific speed with fixed blades. In a few instances, on account of some special condition as to variation of head and flow, turbines with manually adjusted blades have been used. There are only two small installations of Kaplan runners in the country.

Francis turbines of moderate specific speed perform advantageously at part load, and give high efficiency at and near full load. The more recently developed fixed-blade-propeller-type turbines reach maximum efficiency nearer maximum capacity than the Francis turbines. Kaplan turbines (that is, with governor-operated blades) perform excellently on part load, but do not reach the high maximum efficiency of the fixed-blade-propeller turbine. Hence most of the Canadian plants are equipped with moderate-sized turbines, of the Francis and fixed-blade-propeller types, which, with inter-connection of systems, constancy of river flow, and multiplicity of units, effect high generating efficiency. At the same time there is less hazard of seriously reducing the capacity of a system with units out of service, as would be the case were units of the greatest feasible capacity used. It is also noticeable that most of the recent power schemes are being developed along similar lines, variation being governed only by local topographical conditions. Such installations as Chats Falls, Shawinigan, Back River, and Beauharnois in the East, and Seven Sisters, Slave Falls, and other stations in the West, show great similarity in the size of units and auxiliary equipment.

Propeller turbines of the largest size under heads greater than in use elsewhere for this type, were installed first in Canada, and have led the way to their adoption under still higher heads in other countries. The installation of 33,000-h.p. units, having a specific speed of 131 under a head of 60 ft., at La Gabelle is a case in point. The Kaplan-type turbine has so far only been used for smaller installations where high kilowatt-hour output under very variable head and water conditions is essential. Certain of the larger medium-head stations, where Francis or propeller-type units are installed, are provided with additional space, which will be utilized for installation of Kaplan turbines whenever the demand warrants it.

Table I gives general data regarding a number of recent important developments.

Scroll casings, molded in concrete with improved elbow-type draft tubes are usual for heads up to 90 ft. For gates, runners, and seal rings, the material used is in general a good grade of cast iron, cast steel, and plate steel. Bronze is now seldom used. The chief reason for the change in attitude regarding selection of materials is the progress that has been made in the art of electric welding, whereby such materials as stainless steel and other anti-rusting alloys may be used for the repair of eroded surfaces. Parts subjected to rapid erosion can be coated with anti-rusting material, and, with reasonable care, maintenance work has been reduced considerably. Most of the Canadian

TABLE I. DATA ON RECENTLY BUILT CANADIAN HYDRO-ELECTRIC DEVELOPMENTS

Development	River	Head ft.	H.p. per unit	Speed, r.p.m.	Specific speed	No. of units installed	Horsepower Installed	Horsepower Ultimate
Alcoa Power Company	Saguenay	150	65,000	120	58	4	260,000	260,000
Montreal Island	Back River	26	12,000	85.5	160	6	72,000	120,000
Beauharnois	St. Lawrence	80	53,000	75	73	4	112,000	636,000
Chats Falls	Ottawa	53	28,000	125	146	8	224,000	280,000
La Gabelle	St. Maurice	60	33,000	120	131	5	165,000	165,000
High Falls	Lièvre	180	30,000	180	47	3	90,000	120,000
Masson	Lièvre	185	34,000	166.7	45	4	136,000	136,000
Abitibi Canyon	Abitibi	240	66,000	150	42	5	330,000	330,000
Alexander	Nipigon	60	18,000	100	81	3	54,000	72,000
Great Falls	Winnipeg	56	28,000	138.5	128	6	168,000	168,000
Slave Falls	Winnipeg	30	12,000	94.7	148	2	24,000	96,000
Seven Sisters	Winnipeg	66	37,500	138.5	143	3	112,500	225,000
Ghost	Bow	108	18,000	150	60	2	36,000	54,000
Corra Linn	Kootenay	53	19,000	85.7	82	3	57,000	57,000

power corporations have been successful in repairing eroded cast iron to such a degree that almost continuous service is secured without expensive replacement.

The structural design in general employed at medium-head plants is the open-type or separate-stay-vane construction. This has many advantages in setting, removal of internal casting stresses, and easy handling in shops and field. Another advantage is gained in tying together the turbine structure and reinforced concrete, whereby the whole setting acts as a homogeneous unit in resisting the stresses induced by high-water pressure on large areas.

Wheel pits, head covers, bearings, and auxiliary equipment have undergone simplification, and one is sometimes amazed at the clean appearance of recently built power houses in comparison with older plants in existence.

For higher heads, the use of the spiral casing as a housing for the turbine parts still prevails; however, instead of cast iron or even cast steel, riveted steel plate constructed in circular shape as a continuation of the penstock is mostly used. An outstanding plant in this respect is the one now under construction in the Abitibi Canyon under a head of 240 ft., with a capacity of 65,000 h.p. per turbine unit.

For a number of years it was thought very important that specially designed draft tubes be constructed to give the proper diffusing effect and thus increase the efficiency of the turbines. In a number of instances rather unpleasant experiences have been encountered, and alterations

were made with corresponding improvement of output and efficiency. Recent installations with comparatively short elbow-type draft tubes, and even with short, straight-cone-type plate-steel draft tubes, have given in test excellent results as to efficiency and general performance when combined with high-specific-speed runners under relatively high head. More recent practice shows the adoption of improved elbow-type draft tubes with a fairly long horizontal element, thus reducing the high velocity in an unrestricted channel to a low velocity in the actual tailrace.

Turbine bearings are made in various forms. So far, preference has been given to the lignum-vitae water-lubricated type, and in recent installations water-lubricated rubber-lined bearings are being used with good results. While it is a recognized fact that oil-lubricated bearings are superior in some respects to any other type, their disadvantages, owing to the necessary accompanying auxiliary equipment, outweigh the apparent power loss by friction and the frequent removal of the water-lubricated types.

For lubrication of the moving parts in the turbines, industrial alemite grease lubrication is used in nearly all plants.

Governors and Governing Systems

The governors in use in all recently built plants fall into two classes: first, those with light, sensitive flyballs and compensating devices to which every conceivable automatic control feature is readily applicable; and, second, those with heavy flyballs, highly sensitive compensation, and quick-acting servomotor control. While there is variety in design and appearance, these all follow the same principle in performance. The pressure medium used in servomotors to move the gates is usually oil of fairly high viscosity.

Pumps are now invariably of the gear type, direct connected to electric motors. The pumping rate is controlled by unloader valves, pressure-limit valves, and float-controlled valves, thus eliminating unnecessary oil circulation under high pressure and wastage of power. The recent trend has been toward reducing the pumping capacity by the adoption of larger pressure tanks, thus also eliminating unnecessary heating of the oil.

Central pumping plants, so often favored, have been superseded largely by the so-called "two-unit pumping system." This system is applicable to power plants where four or more units are installed. The governors and pressure units are interconnected in pairs, and so proportioned that one pump, including the tank equipment, can handle the servomotors of two units. In this respect the two recent installations of large size, at Beauharnois and Chats Falls, are similar.

Belt-driven apparatus has more or less disappeared, and electric drive for flyball motors, as well as for any other equipment, is used in all modern stations.

Reference should be made here to a new departure in flyball drive for governors which promises to overcome certain objectionable features of the electric drive. This is the adoption of a permanent-magnet generator

mounted on the turbine shaft, furnishing power for the flyball motors independently of any other source of power, and unaffected by any changes except changes in speed of turbine shaft. This innovation is now installed in one of the power stations of the Hydro-Electric Power Commission, where turbines of low speed (100 r.p.m.) are operating.

(*Continued in December's Issue*).

Port Arthur Transformer Station

New Relay Protection on 110 kv. Lines

By H. H. Leeming, Assistant Engineer, Electrical Engineering Dept., H.E.P.C. of Ont.

AT the time the electrical system for the Alexander Power Development was being designed, considerable study was given to the improvement of the synchronous stability of the Thunder Bay System due to the susceptibility to voltage disturbances of the large synchronous motor and paper machine loads of many of the important customers.

These studies showed the importance of rapid clearance of any fault which would cause any considerable drop in voltage to the respective customers. To meet this, a scheme of connections for the system was developed based on the use of isolated 110 kv. lines and high speed protective relays of the latest design.

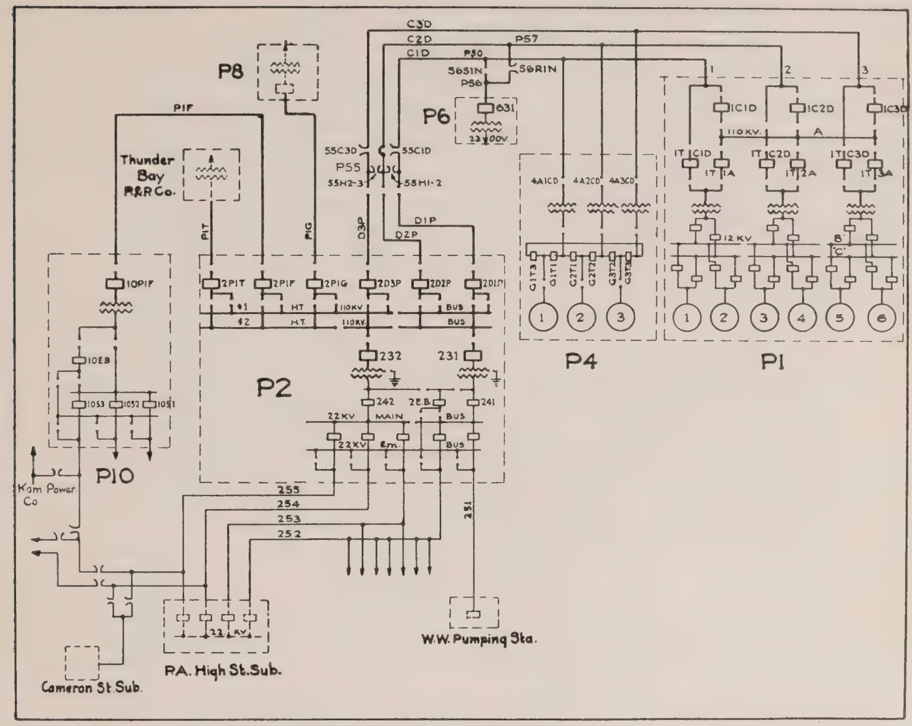
The extent to which the isolation of the 110 kv. system has been carried out to date will be observed by reference to the following system diagram.

High speed relays were provided for the Alexander Generating Station and the original 110 kv. line relays at the Cameron Falls Generating Station replaced with similar relays. The system as a whole could not, however, obtain full benefit of the high speed relays installed at the generating stations until the original 110 kv. line protective relays at the Port Arthur Transformer Station were replaced by modern high speed relays for due to the comparatively sluggish characteristics of the original line protective relays at this station, line faults, particularly those developing near the latter station would persist for a sufficient length of time to cause a considerable disturbance on the system which generally resulted in a partial or total loss of the system load.

Thus co-ordinating with the line protective systems at the generating stations in quickly isolating a faulty 110 kv. line, new high speed relays are being installed on all 110 kv. lines at the Port Arthur Transformer Station.

The general characteristics of the new protective relay system for the 110 kv. lines at the Port Arthur Transformer Station is as follows:—

Each incoming 110 kv. line is equipped with a Westinghouse high speed impedance distance-directional type HZ330, 3 phase relay to protect



Thunder Bay System Diagram.
P1—Cameron Falls Generating Station.
P2—Port Arthur Transformer Station.
P4—Alexander Generating Station.
P6—Nipigon Corporation Transformer Station.
P8—Great Lakes Pulp and Paper Company Transformer Station.
P10—Fort William Transformer Station.

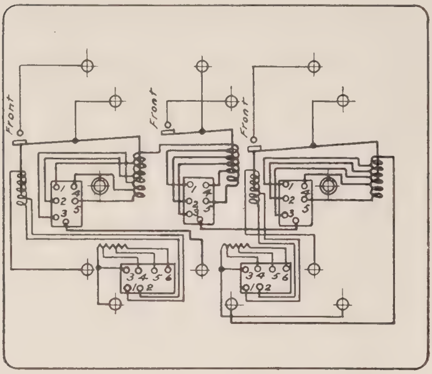
against phase to phase faults and one Cansfield high speed, XC3-A neutral current relay for phase to ground faults.

The HZ330 relay is of recent design, containing three directional elements and three impedance elements. The directional element is of the low energy wattmeter type, its contacts are normally open for power flow towards the Port Arthur 110 kv. bus but instantly close on power reversal, thus preventing the respective line tripping for a fault on the Port Arthur h.v. bus or beyond. The impedance element is of the current-potential balance type which will be set to ensure positive line clearance for faults to the extreme end of the line.

The contacts of the directional and impedance elements are in series and will operate to energize the line breaker trip coil in 0.01 secs. or less.

The following diagram illustrates the internal connections of the HZ330 relay.

The XC3-A neutral current relay for the phase to ground protection is of a comparatively simple plunger



Connections of the HZ330 Relay.

type and operates on the current unbalance in the three phases of the respective 110 kv. line. It trips the line breaker through a type XF34 multicontact relay. The setting of this feature allows for rapid and positive clearance of line-to-ground faults with high fault resistance under minimun system operating conditions.

The combination consisting of the XC3-A and XF34 relays will operate to energize the breaker trip coil in about .06 to .1 second. This feature is non-directional since on this system ground fault current can only flow in the faulty line. The system is grounded only through the neutrals of the transformer banks at the Port Arthur Transformer Station.

For the 110 kv. outgoing line supplying a large paper mill at Fort William, the protective relay equipment is exactly similar to that on the incoming lines. In this case, however, the directional element of the HZ330 relay is normally closed for power outfeeding from the 110 kv. bus but will instantly open on power reversal, thus preventing the line from tripping on synchronous back-feed to a fault on or beyond the Port Arthur 110 kv. bus.

The relay protective equipment for this line is designed to provide fast, adequate protection against a phase-to-phase or a phase-to-ground fault over the entire line.

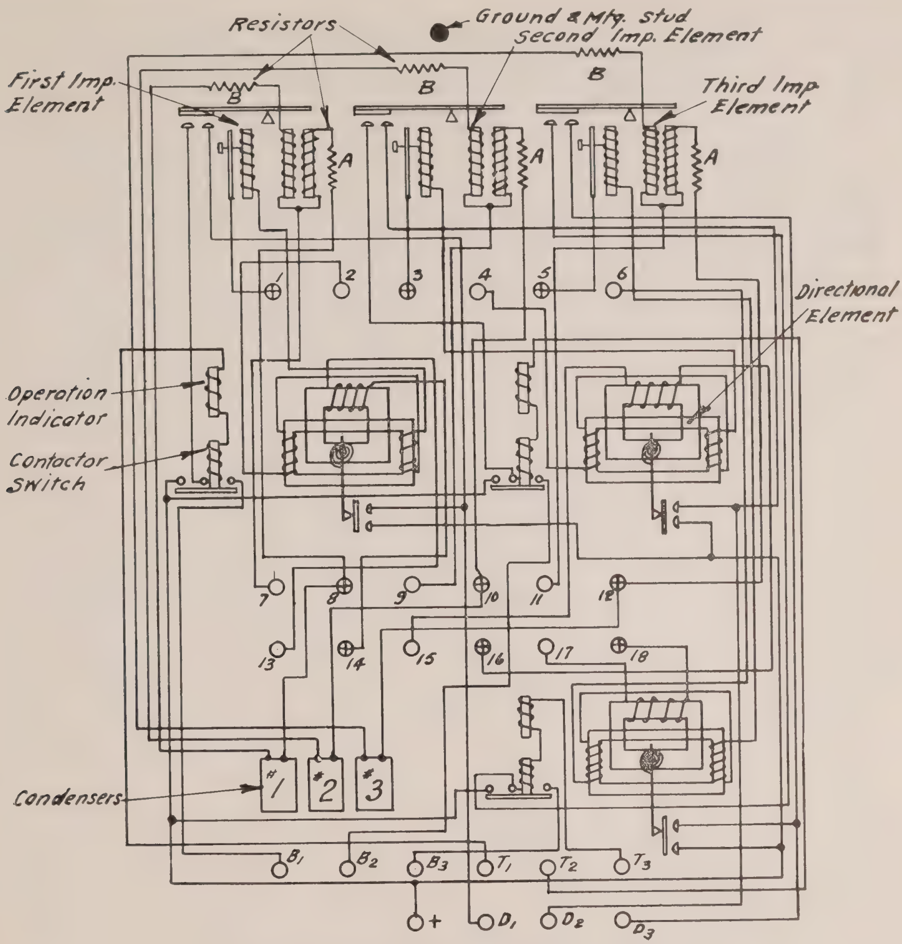
On the two other outgoing 110 kv. lines from the Port Arthur Station, the protective relay equipment consists of three single phase, Cansfield, XC7-B impedance-distance relays for phase-to-phase faults and one XC3-A neutral current relay for phase-to-ground faults.

The following diagram illustrates the internal wiring of the type XC7-B relay.

The XC7-B relay consists of two impedance elements of the current potential balance type and one excess current element similar to the XC3-A relay. The contacts of the excess current element are connected in series with the paralleled contacts of the two impedance elements. The former element is used to prevent the relay from operating when the impedance element is not definitely overbalanced to closed position. The impedance range of one element will provide fast, adequate protection for the entire 110 kv. line. The second impedance element will be used to provide "backup" protection for L.V. faults on the receiving station equipment.

The instantaneous impedance element energizes the trip coil of the breaker through an XF34 control element in about .06 to .1 second.

The "backup" impedance element operates a timing relay which in turn energizes the breaker trip coil through the above XF34 element.



Internal wiring of the type XC7-B Relay.

Since backfeed from the customers supplied by these two 110 kv. lines is negligible, a directional feature is not required at the present time.

In order to decrease the time required for a 110 kv. line breaker to open, once the trip coil has been energized, certain changes will be made to the existing breaker contact mechanisms.

The Foundations of Science

By W. F. Sutherland, Engineer, Toronto Hydro-Electric System

(Presented to Toronto Section A.I.E.E., on October 28th, 1932.)

BEFORE considering the foundations of Science, it might be well to ask one's self why there is such a thing as science at all? The answer to this question may illuminate all other and further considerations of this branch of learning to which we, as engineers, owe our very livelihood. For the control of the forces and materials of Nature to the benefit of man is the function of the engineer; the acquisition of the knowledge which necessarily precedes control is the function of the scientist. What, then, prompts the scientist to probe deeply into the mysteries of Nature, as he is in the habit of doing?

One can only conclude that Science arises out of that deep and characteristic motivation or drive which distinguishes man from the rest of the animal kingdom—his quest for Truth. There are, of course, other things which seem to so distinguish us (at least we claim they do) but there are few which faii to break down under analysis.

There are, for instance, the popular ideas concerning mind and soul. Some of us say we have mind, others say soul, and still others may claim possession of both. And most of us are unanimous in denying possession of these things to the birds of the air or the beasts of the field. Assertion, however, is not proof and we experience great difficulty in endeavoring to substantiate our possession of these things and our uniqueness in this possession. Curiously enough, in this attempted proof, we encounter one of the limitations of science.

We endeavour to substantiate our superiority, and by virtue of it our possession of these higher things, by reference to our attributes and our accomplishments.

Among the attributes are those of speech and reason and certain physical differences. We say we are much better able to cope with our environment through the faculty of reason; we say our speech is far more complex than that of the animal; and we say also that the necessity we are under of having to clothe ourselves also differentiates us.

But the biologist, who is a scientist of sorts (perhaps not a very good one) throws cold water on our attempted proofs and answers that such differences as he can find are only of degree —not of kind. If we possess greater reasoning powers, it is only on account of the greater development of our cerebral hemispheres. Likewise, this development has given greater scope to memory and associative tracts and our speech is likewise more complex. Again, the fact that we require coverings for our nakedness is only a matter of genetics—breeding. We may be a sport like the Mexican hairless dog. He thus refutes every argument we advance.

Disappointed here, we turn to our accomplishments in substantiation of

our claims to superiority. We cite our modern means of transportation, our cities with their skyscrapers, sanitation, public utilities, and so forth. We use radio and other means of communication, likewise. In short, our culture would appear to differentiate us.

Then the Naturalist has his say. He also is disappointing for he points to the ant, perhaps, and says: "The ant is quite as wonderful as we for he lives in cities, wages relentless wars, rears his young more skilfully than we, keeps insect cows, and all in all behaves much as we do, only in the measure of his talents." The bee, likewise, can be used in refutation of our arguments and many other animals, living in perfect adaptation to their environments. So the Naturalist gives us cold comfort.

It is rather foolish on our part to seek proofs in the physical realm for things of a non-physical nature. It is hard to prove the things of the spirit by those of the flesh. And science, much as we appreciate the wonders it has wrought, is of the earth-earthy.

* * * *

At any rate, we are left with our curiosity. We are the most inquisitive animals on earth. Not that other animals are incurious,—far from it. We all know of the curiosity of the family cat, which leads to its untimely death. And we know our dogs are also curious. Many other instances come to mind. But these animal curiosities revolve around the preservation of the individual and the perpetuation of the species. We have them also and they give us the urge, show us the way, to earn our daily bread and to acquire our family responsibilities.

But beyond and above them, we have another and a greater curiosity. We wish to take the world apart, to see what makes it go. We are also curious about ourselves. We wonder what we are, whence we came, and whither we are directing our course. In other words, we are searchers after the truth.

It is this search that has given us our language, for language consists of words denoting the relations between things and these relations are truths found out during countless ages of searching on the part of mankind. The search has given us our literature, in which we find the truth about life as the author sees it. It has given us our Arts, for they in turn convey truth to us via the emotions; and our religious endeavour to express the truth about ourselves.

And lastly, the search for truth is responsible for the one thing in our culture which does distinguish it from that of the lesser creatures. Our culture is not static and changeless like that of the ant or bee; rather, it is dynamic. It is never the same from day to day. Sometimes human culture changes slowly, sometimes fast, but change it always does. At present it is changing overnight. Our progress has been at a greatly accelerated rate since the beginning of this century. We now have an engineers' civilization based on science and to them we owe the culture of the present.

* * * *

As a matter of fact, Science is a specialized form of the quest for

truth. It has a definitely circumscribed objective and a definite type of procedure. The objective is the truth concerning the nature of the Physical Universe—the things around us. Science does not investigate the scientist—he is taken for granted, and if, by chance, a scientist should turn to the study of man, it is always the other man—not the scientist himself. Too much stress cannot be laid on this point. Science is objective, never subjective. The latter leads inevitably into mysticism, the antithesis of Science.

This limitation in objective, this narrowing down of the field under review to the external, is altogether likely the consequence of the method Western Science has adopted. The adjective "Western" is used, for there have been other sciences with different aims and objects and different methods of achieving them. For instance, Astrology is fully as much a science as Astronomy. Alchemy likewise as compared to Chemistry. But these two sciences belong to an older and different culture and possess different methods, different aims and objects, so we do not understand them and pass them by. They were directed to the study of mankind and not so much to his environment.

Our science had its rise with Aristotle, for to him we owe the beginnings of the scientific method. He gave to the world two things which our science uses — the experimental method and a systematic logic. The experimental method might be called the bow and logic the arrow. Science uses both experiment and logic,—the bow and the arrow.

Aristotle was the first great experimenter, the first great collector of data and its first great codifier. He was also probably the finest logician of all times but, unfortunately, he did not quite succeed in uniting these two fruits of his colossal genius. This was left to later men, also famous on the pages of history—Gallileo for one. Gallileo is famous not only for his astronomical mix-up with the church but also for his experiment with the falling weights from the leaning tower of Pisa. He was probably the first to check the fruits of logic by experiment.

Logic by itself is a tool we all use. We think logically, unless we are insane. Our speech betrays logic in its connected sequences of thoughts and our mathematical equations are merely shorthand for logic that we are too lazy to think through entirely on the mental plane.

And there is a beautiful co-operation and interdependence in Modern Science between the logic of our thoughts and the results of our experimental actions. For it is difficult to say where experiment leaves off and reason begins. Again, Modern Science is a two-sided thing—it uses experiment to derive its laws of nature and uses experiment once again to prove them when they are found.

Science examines the universe around us, the particulars of experience, events as we call them, and it does so in a particular way. It is our immediate concern to examine this particular method, to find out more about it and to answer questions relative to its validity. We can ask ourselves as to what extent our science gives us a true picture of external

Fig. 1.

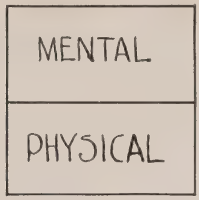


Fig. 2.

things, what its limits are and whether science can rightfully answer questions concerning man himself and his nature. This latter question is an important one and to evaluate the limits of our scientific method in respect to it is equally important. For the world of events is like a pudding. It has an inside and an outside. It is difficult to say which is the most important; certainly the inside is, to the pudding itself.

Imagine now that the blank area on this page outlined by the border of Fig. 1 is the field in which science operates. It is the world of events. Being blank, it is meaningless much as is the world to an infant when he surveys it for the first time. Closer scrutiny will, however, reveal the fact that the very blankness of the area possesses substance—the paper itself. There is something there, an infinite array of fibres, all inextricably mixed. These are material and concrete, tangible, They can be called the particulars of experience, events which it is the purpose of us, as scientists, to investigate.

How are we going to proceed? We will have to break them up into groups or divisions, classify them, differentiate them, for easy understanding. The easiest way to do this is to draw a line across the area as in Fig. 2. Let us now call the top half the mental world, the bottom half the physical world. We have thus made a clean-cut division between the two major types of phenomena.

The scientist himself possesses both mental and physical characteristics and so, logically, should appear in our diagram. All right, let us represent him by a circle (Fig. 3) bisected by the line between the physical and mental. Let us next call the top semi-circle the thinker, the bottom the observer, for it is the physical part of the scientist that does all the observing, the weighing and measuring which in the last analysis is the essence of the experimental art.

The diagram is an extremely apt one so far, since only the thickness of a line separates the scientist from the world outside. Indeed, the farther one goes in philosophy the more difficult it is to separate the thing outside and the thing inside. It is hard to say just what the ego, the man himself, really is. Still harder is it to say what is and what is not of him. This is just in passing; now for the method of science. Let us place the words "Experiments on Particulars or Things" at the bottom

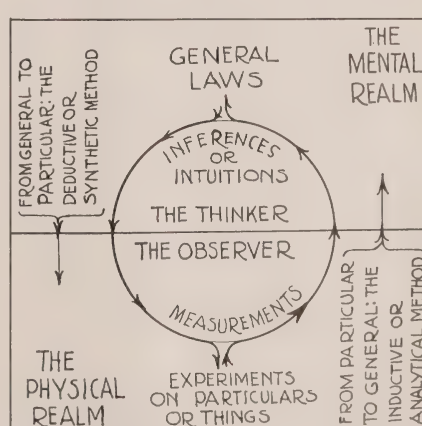


Fig. 3.

of the circle. Let us then place arrows on the circle leading counter-clockwise—the way all electrical engineers proceed about their business. So that we can go from experiments up the right-hand side of the diagram up toward the mental realm. In other words, we first make experiments and then reason about them.

But we do this in a particular way. We cannot hope to master all the infinite details of the things we observe so we extract from these, things that are common to all of them. We show the general out of the particular. Those who are logicians can now label the right-hand side of the circle, the inductive or analytical method—from particular to general.

What is the result of this ascent from the details of experiment to the realms of reason. It is the general law—the Law of Gravitation, Ohm's Law, any so-called law of nature. Newton reasoned thus when he gave to the world his laws of motion and those relating to gravitation. No doubt the apple which is reputed to have hit him on the head was only one of a number of phenomena which he had observed or which had been drawn to his attention. Apples had fallen before Newton's time, other things had always acted under the influence of gravity, but it took the mind of Newton to draw all these things together and to extract from them the one thing common to them all—their behavior under this influence of gravity. Their behavior when analyzed gave rise to the Law of Gravity.

Now we are prone to consider such a law or any law to which we give the name of Law of Nature a fixed and immutable thing, everlasting as the hills to which the psalmist lifted up his eyes. Unfortunately, they are no such thing, for they are merely our guess as to how Nature plays her game. As guesses, they require verification and checking before we can even place any confidence in them within the range of ordinary experimental observation.

So then, and now, we have recourse to the left-hand side of the scientific circle. Having ascended to the airy heights of mind and having pulled down our law of nature from some intuitional or inferential realm, we proceed to check it by the cold, hard matter-of-fact world of experience. Having gone from the particular to the general, we now return from the general to the particular once again. We make deductions now, and we can listen, perhaps, to Newton saying:—

"Now if this law I have found concerning gravitation works on earth here over the limited range in which I have experimented, it should also work on a much greater scale, even on the scale of Sun, Moon and Planets." So he set to work and quite easily by his laws found that the planets should behave just as by observation we know them to behave.

So, in Science, we start from the world of experience. We make experiments on it, then reason from these experiments to general laws. We then reason back from these general laws down to the world of experience again. And so we pursue a circular course from physical to mental, from mental to physical again. Rather a merry-go-round idea, isn't it? And if we come out at the point from which we started, how

is science so all-powerful in making for our progress by so continually dishing up new things for us to use and play with?

Actually, the path is not circular, we only see it so in plan. For the path of Science is helical or screw-like. While it is true that we go from experiment to experiment, from physical back to physical, we end up with a new set of experiences. Newton may have started with the apple but he definitely ended up with the planets.

But, then, wonderful and all as Science is and helpful as it is to us, the things we gratefully accept from her are only the by-products of her quest. The true scientist is more interested in his general law or Law of Nature than in its application. The Electro-Magnetic Theory of radiant energy is of more importance to him than its applications in radio.

His Quest for Truth is all important. Has he, then, any assurance that his Laws represent the truth of things—the ultimate truth concerning that small cross-section of the world surveyed? It is to be feared not, for certain assumptions, somewhat akin in nature to the axioms of Euclid, have to be made on the upward arc or reasoning. These the scientist does not verify, probably in the very nature of things, he cannot.

Certain notions of space and time, matter and force are used in science. And these notions form a complete and coherent system. They mutually support each other and form a coherent whole, much as do the members a bridge engineer uses to form his completed structure. In tact, the scientific method has much in common with bridge building, for the scientist builds a bridge with his concepts to span the gap across the unknown. Unlike the engineer, who deals with material things, the members of the scientist's bridge are mental–space and time, matter and force, and a few others like them. We can, however, build up a sort of bridge diagram out of them in spite of their mental character, as in Fig. 4.

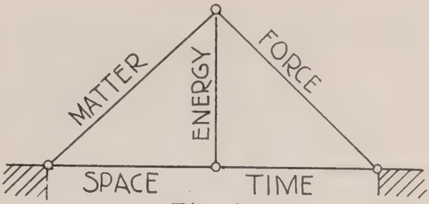


Fig. 4.

Since there is a linkage of one concept to another, as with the members of a bridge, it is evident that the shape of the completed structure not only is something in itself, but it also must determine the characteristics of the conceptual linkages used. Space and time, for instance, cannot be anything but must have certain characteristics. The shape of the scientists bridge is determined, that is for the classical science, before relativity and the electron, by the law of causality, effect following upon cause. Consequently, space and time have certain characteristics, the chief among them being this, that time is absolutely divorced from space and space from time. Otherwise, we might conceivably transform one into the other and find effects preceding the causes which created them.

This self-consistency amongst the concepts used in science, can also be seen in the matter of definition. Have we any justification for saying

that these things we call space and time, matter, force and energy, have any real existence? It is doubtful, for we run into difficulties the moment we define them.

Try matter. Matter is that which exists in space and endures in time. What is space? That which matter exists in. What is time? That which gives duration to matter. The whole structure is self-contained and necessarily so. One cannot conceive of time without matter nor matter without time.

Again, the bridge of the scientist can have no redundant members. We all know how wobbly a linkage composed of four members is. (See Fig. 5a). It lacks completeness. Add one more link as in Fig. 5b. The linkage becomes complete and rigid. It is useful and the stresses are easily calculated. Add another link as in Fig. 5c. The stresses are are now indeterminate and quite difficult to calculate.

So it is with science; the skeleton on which all her theorizing is done is a mental framework, complete in itself, quite rigid and useful. It is self-sufficient, too much so indeed for it will not admit of other things which we, as human beings, believe exist. It will not admit of free-will, for instance, for free-will would upset the law of causality and this in turn would necessitate a revision of all the other concepts,—space and time, etc.

Science can never bring out of the magician's hat anything more than she puts into it. The magical eggs she places therein are those of space, time, matter and force, energy and other things perhaps of like nature. The omelet she pulls out of the hat is only these same things mixed up in some new way.

Science does not include free-will nor mind amongst the premises on which her theorizing is done. Consequently, she can never find them. Worse still, these things and others of their kind are dangerous things to have lying around loose, and so Science, or some scientists rather, have been in the habit of denying them.

A splendid example of the limitations of Science concerning things of a non-physical nature is the futility of endeavouring to prove the existence or non-existence of telepathy and psychic phenomena by scientific procedure. Such things may or may not exist, (that is beside the point) but if they are amenable to the scientist's foot-rule, to his experimental method, they are always duplicable by much the same procedure and the possibility of fraud is thus almost impossible to detect.

In the classical science, then, the law of causality, with its consequent limitations of other concepts, reigned supreme. The world was mechan-

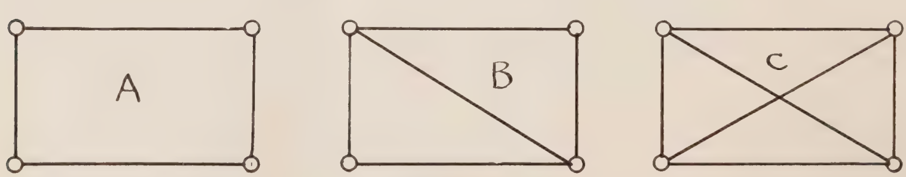


Fig. 5.

istic and materialism was the inevitable conclusion.

That is, until relativity came along.

* * * *

One of the things relativity did was to fuse space and time into a curious fourth dimensional thing. Time was no longer divorced from space but mathematical expressions were devised whereby events could be described in a sort of space-time frame of reference or system of co-ordinates. Time was now related to the three directions of space by an operator, containing the old familiar symbol of $\sqrt{-1}$ which we, as engineers, know and use in dealing with events, vectors or what not, in three space. Associated with this symbol was another one relating to the velocity of light. The only thing really remaining to distinguish the time direction from the three space dimensions was, and is, this velocity of light.

Now, this small change in the fundamental concepts used in Science appeared to be a very simple and innocent thing to do. It helped a great deal and apparently did nothing much in the creation of new difficulties. Bear in mind, however, that simple and all as it looked, the change was one in fundamentals, in the very foundation and groundwork of Science. Heretofore, the space-time concepts of science were those of the common man, whose common-sense told him that they did bear some close approach to reality. Here, in relativity, was another sort of space and time, one with which the ordinary individual could do nothing. There were those, however, who had played with fourth-dimensional ideas long before relativity came on the scene and these had postulated many curious properties to a space and time associated together in a manner exactly similar to that of Einstein, Lorentz and other pioneers in relativity. They had said that a being endowed with ability to operate in four dimensions could alter the hand of gloves, undo knots without untying them, could alter the position of the viscera in the body, could pass through walls and do many other curious things. Much of this may be pure fantasy but, strangely enough, these advocates of a four-dimensional existence were quite insistent that from some such arrangement came those things in man we find so hard to classify and prove—mind, reason, intuitions and, most important—free-will. Scientific circles, naturally enough, gave short shrift to such ideas.

The scientist has been quite earnest in disavowing these higher metaphysical implications of his act. But, nevertheless, they are still there and have even obtruded themselves into science itself.

For, gone now are our old familiar definitions of matter, time and space. Gone now is the beautiful simplicity which marked their relations one with another. The old familiar bridge analogy fails to work for us. We have destroyed the simplicity of its linkages. We have made one of the hinge points flexible and ambulatory, as in Fig. 6. It can move along the bottom chord at will, just as does the slider on a potentiometer. We can have any desired combination of space and time at will, just by jumping out of one reference frame and into another.

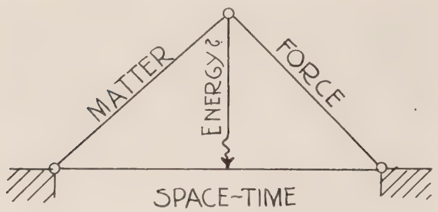


Fig. 6.

Now if there is anything in logic at all, such considerations as these must lead to an alteration in our ideas of causality. They must lead to a different idea of the Universe, a more flexible one and perhaps one in which we, as ordinary mortals, may find a place. The older idea of causality was framed around the older ideas of space, time and matter. It was consistent with them and gave consistent results.

These newer ideas in turn must lead to a revision in our understanding of the laws of cause and effect. Eddington's comment on the newer space-time relationships is in the form of a well-known Limerick:—

"There was a young lady named
Bright,
Whose speed was much greater
than light,
She went out one day in the usual
way,
And came back on the previous
night."
(Cause and effect here would seem
to be inverted.)

Perhaps someone may recognize the full metaphysical implications of relativity. Perhaps they will be forced on science through results springing out of its own work.

Indeed, this is already the case, for recent researches into the physics of the electron have established the fact that it possesses a perversity strangely like that of human kind. It is now admitted that the electron cannot be defined in respect to velocity and position simultaneously. We can state its position, for instance, but then we cannot know its velocity. Or we can state its velocity, but then are equally at loss to find its position. This anomaly has given rise to that famous principle enunciated by Heisenburg and bearing his name—The Principle of Uncertainty. Some physicists say this ignorance arises out of our inability to weigh and measure the electron; others say it is inherent in the very nature of the thing itself.

It is a curious thing that the Principle of Uncertainty remained unsuspected until the relativity mathematics was applied to the electron and then this so-called principle which is really denial of our older law of cause and effect made its appearance. The soil was ready and it naturally grew to the surface of our scientific thought.

* * * *

Science now is like the adolescent youth whose voice partakes in turn of the bass and tenor qualities. It hardly knows just where it stands, glancing back over the closing days of its youth and looking forward to man's estate with all the promise of a glorious future. For we seem to have two sciences in our midst—an older one now called the "Classical", the one which dates back to Aristotle in its origins; and a new one hardly named as yet but seeing a new vision of things through the twin pillars of electron and relativity.

And we are finding both sciences useful. The classical still serves us well in the things of size commensurate with ourselves. The newer science finds its sphere of usefulness in those realms of speculative thought concerned with the almost infinitely small and the equally great.

D. W. McBurney, Hagersville, Twenty Years Hydro Chairman

D. W. McBurney

D. W. McBurney, Chairman, Hydro-Electric Commission, Hagersville, has recently completed twenty years as Hydro chairman in that municipality.

The Hydro By-law was passed by the Village of Hagersville in the year 1912, when Mr. McBurney was Reeve, he having served in that capacity from 1912 to 1914, following one year on the Village Council. From that time until the formation of the Local Commission in Hagersville Mr. McBurney served on the Village Hydro Committee as Chairman, and has continued as Chairman of the Hydro Commission since its inception.

Mr. McBurney is a native of Haldimand County and has lived in that County all his life, excepting seven years spent in Winnipeg. During the last twenty-six years he has been a resident of Hagersville.

In addition to his services to the Village Council and the Hydro System, of which he has always been a very enthusiastic supporter, Mr. McBurney has served as County Road Superintendent for seventeen years and is still holding this office.

The *Bulletin* wishes to congratulate Mr. McBurney on his completion of twenty years of Chairmanship of a system having very successful operation. No doubt this success and the resulting many satisfied customers has been due to his untiring efforts.

Albert O. Hunt, London

Albert O. Hunt, for the past twenty years Assistant General Manager of the London Public Utilities Commission, died at his home in London on November 21, 1932, following a brief illness from pneumonia.

Mr. Hunt was born in London, Ontario, in 1867, and received his education in London and Toronto schools. In 1888 he joined the staff of the Royal Electric Company, Montreal, where he served in various capacities until 1894 when he returned to London to become Superintendent of the Canadian General Electric Company plant in London, which later became the London Electric. When the London Electric Company took over this plant Mr. Hunt continued as Superintendent and progressed through various posts in that firm to the position of Manager. In 1912 he transferred his activities to the London Public Utilities Commission where he was appointed Assistant General Manager. In holding this position he witnessed the development and growth of the London Public Utilities Commission from its beginning.

Surviving him are his widow, five sons and one brother to all of whom the *Bulletin* extends sincere sympathy.

Association of Municipal Electrical Utilities

NOMINATIONS FOR 1933 OFFICERS

The Scrutineers' report giving the results of the Primary Ballot for 1933 Officers of the Association of Municipal Electrical Utilities, shows the following names, those to appear on the Election Ballot being indicated by a star (*).

PRESIDENT: *T. W. Brackinreid, D. B. McColl, *C. E. Schwenger, E. V. Buchanan, R. S. Reynolds.

VICE-PRESIDENT: *W. R. Catton, *D. B. McColl, J. E. Skidmore, O. M. Perry, H. F. Shearer, W. E. Reesor, T. W. Brackinreid, R. H. Martindale, E. V. Buchanan, A. L. Farquharson, W. M. Rogers, A. B. Manson, R. S. Reynolds, O. H. Scott, R. S. King, R. L. Dobbin, T. R. C. Flint, W. G. Breen.

SECRETARY: *S. R. A. Clement, *W. B. Munro.

TREASURER: *H. T. Macdonald,

W. B. Munro, *R. P. Darrell, *D. J. McAuley, *B. Farchney.

DIRECTORS (*from the membership at large*): *R. L. Dobbin, *O. H. Scott, *E. V. Buchanan, *V. S. McIntyre, *J. E. Skidmore, *E. I. Sifton, O. M. Perry, C. J. Moors, D. B. McColl, E. J. Stapleton, R. S. Reynolds, J. E. B. Phelps, H. F. Shearer, R. S. King, J. W. Peart, A. B. Manson, P. B. Yates, J. E. Teckoe, M. W. Rogers, T. R. C. Flint, S. Bucknell, W. H. Childs, G. W. Chase, R. H. Martindale, R. J. Smith, A. E. Ternan, A. B. Scott, J. R. Price, W. E. Reesor, G. A. Parrott, W. D. Stalker, C. H. Denton, A. McFarland, H. E. Fairfield, C. Kranz, J. E. Brown, H. G. Hall, J. L. Millard, C. A. Walters, R. H. Staford, J. G. Archibald, R. S. Belfry, A. M. Bowman, G. F. Shreve, A. W. J. Stewart, E. E. Lyons.

DISTRICT DIRECTORS:—

NIAGARA DISTRICT: *R. S. Reynolds, *A. B. Manson, W. H. Childs, E. I. Sifton, D. B. McColl, J. E. Teckoe, J. W. Peart, H. J. MacTavish, W. R. Catton, H. F. Shearer, J. W. Bayliss, A. B. Scott, J. G. Archibald, R. B. Hanna, J. A. Donaldson, Miss M. Grant, J. E. B. Phelps, T. C. Savage, C. F. Tumelty and E. V. Buchanan.

GEORGIAN BAY DISTRICT: *R. S. King, *W. W. Marshall.

CENTRAL DISTRICT: *C. A. Walters, *G. E. Chase, J. E. Skidmore, R. O. Quick, E. R. Smithrim.

NORTHERN DISTRICT: *C. J. Moors, *R. H. Staford.

EASTERN DISTRICT: *M. W. Rogers, *A. L. Farquharson, J. A. Ross.

O.M.E.A. and A.M.E.U. CONVENTION

at the Royal York Hotel, Toronto

January 24 and 25, 1933

Announcing -

WINNERS IN THE HYDRO LAMP WINDOW DRESSING CONTEST

CLASS 1.

First Prize		Toronto Hydro-Electric System
Second Prize		Hamilton Hydro-Electric System
Third Prize	Tie	Windsor Hydro-Electric System London Public Utilities Commission

CLASS 2.

First Prize		Welland Hydro-Electric System
Second Prize	Tie	Ottawa Hydro-Electric System Chatham Public Utilities Commission
Third Prize	Tie	Galt Public Utilities Commission Oshawa Public Utilities Commission Belleville Hydro-Electric System

CLASS 3.

First Prize		Exeter Public Utilities Commission
Second Prize	Tie	Napanee Public Utilities Commission Trenton Public Utilities Commission
Third Prize	Tie	Ingersoll Public Utilities Commission Brighton Hydro-Electric System

Prizes will be forwarded to the winners as soon as possible.

The Window Dressing Contest held this year was more successful than ever and the judging of the photographs was a real job.

We wish to thank all those who took part for their co-operation and while everyone could not win a prize we trust that those who are not participating in the prize money will be encouraged by their efforts and will endeavour to come into the limelight next year.

SALES DEPARTMENT

HYDRO-ELECTRIC POWER COMMISSION
OF ONTARIO

THE BULLETIN

Published by

HYDRO-ELECTRIC POWER COMMISSION of Ontario

190 University Ave. Toronto

Subscription Price $2.00 Per Year

Economic Value of Good Street Lighting

Report of I.E.S. Committee on Street Lighting.

Abstracted from a Report presented by F. C. Caldwell, Professor of Electrical Engineering, Ohio State University, Columbus, Ohio, before the twenty-sixth Annual Convention of the Illuminating Engineering Society, Swampscott, Mass., Sept. 27-29, 1932.

1. Methods of Attack

CONCERNING the relation of street illumination to traffic accidents, three comparisons may be considered. First, between daylight and complete darkness; second, between daylight and the usual street lighting, which, for the most part, is inadequate; and third, the comparison between the usual street lighting and the highest practicable level, or "adequate street lighting." The first of the above comparisons, that between daylight and darkness, though concerned in the problem of interurban thoroughfares, does not apply to city street lighting, where artificial illumination may always be assumed. For the second comparison, between daylight and the usual, for the most part, inadequate lighting, a considerable amount of data are now available, and this is discussed in Section 2 of this report. The comparison between accident rates for inadequate lighting with those for adequate lighting, provides data of vital importance, which, if correct, are immediately applicable to the problem, the solution of which is undertaken in this report. It is very desirable that a large number of traffic accidents should be studied, and it should be comparatively easy to obtain the needed information from municipal records.

2. Comparison of Daylight and Darkness

As indicated in Section 1, this comparison, though not applicable to city streets, may be applied in the case of the installation of lighting upon interurban throughfares, upon which no artificial light has been

CONTENTS

Vol. XIX No. 12
December, 1932

used. The test was made on the highways of Indiana for the twelve months ending August 31, 1930. Table 1 gives the data for each of the twelve months and the total for the 248 fatal accidents recorded.

TABLE I.

Analysis of Fatalities on State Roads of Indiana September 1929 through August 1930

	Total		
Month	Light	Dusk	Dark
September, 1929	7	0	12
October, 1929 ..	12	7	21
November, 1929	4	3	11
December, 1929	2	0	15
January, 1930 ..	6	0	13
February, 1930 .	5	1	10
March, 1930 ...	5	1	8
April, 1930.....	13	1	8
May, 1930	6	3	11
June, 1930......	8	2	3
July, 1930......	11	2	10
August, 1930 ...	10	2	15
Per cent........	36	9	55

From these data it appears that during the hours of dusk and darkness approximately two-thirds of the fatal traffic accidents on these roads occurred. From a traffic survey it was estimated that about two-thirds of the total traffic was during the hours of daylight and only one-third during the hours of dusk and darkness; thus, one third of the traffic experienced two-thirds of the accidents during the latter period, indicating that the hazard during the hours of dusk and darkness was four times that during the hours of daylight.

3. Comparison of Summer and Winter Evening Hours

This method was first described and used by E. A. Anderson and O. F. Haas, both of the General Electric Company, in November, 1921. In this method a period during the early evening is selected, such that it will be entirely or principally light during the summer months, and entirely or principally dark during the winter months. Two-hour or three-hour periods, covering three or four months, for each season, have been used. The shorter periods have the advantage that they are more completely dark in winter and light in summer, but this is more or less compensated for in the case of the longer periods by the much larger number of cases dealt with.

To use the ratio of winter to summer accidents during this period as a measure of the effect of lack of illumination would assume that all other conditions, affecting in a general way the occurrence of accidents,

were negligible; such effects are—differences in traffic density; street surface conditions as affected by wetness, ice and snow; and weather conditions as affected by rain and fog. A method used by Anderson and Haas to correct for these variables and which has been followed by some other observers is as follows: It is assumed that for certain hours, which are entirely light during both summer and winter, or entirely dark during both, differences in accident rates would be determined by these variables, and that the same difference in accident rate due to them would also hold during the evening test period. If then, the ratio of winter to summer accidents, found from these day and night hours, is applied to the number of accidents for the evening test period in the summer, the expected winter accidents, apart from the effect of illumination would be obtained. Then the difference between this and the actual accidents would show the effect of difference in illumination. The following tests have made use of this method:

(a) Anderson and Haas, General Electric Company for 12-month period, 1919 to 1920, 32 cities. Summer: May, June, July; Winter, November, December, January.

ALL TRAFFIC ACCIDENTS

Hour	Winter	Summer	Ratio
3 to 5 p.m.	1,095	1,429	76.6%
9 to 11 p.m.	495	740	66.9%
Average	....	....	71.8%
6 to 8 p.m.	1,046	1,200	......

Winter accidents, if same ratio held as during 3 to 5 and 9 to 11 periods	1,200×71.8%	=862
Accidents due to inadequate illumination	1,046−862	=184
	184/1,046	=17.6%

(b) National Safety Council, Statistical Bureau. For year 1929, New York, Pennsylvania, North Carolina, and California.

FATAL TRAFFIC ACCIDENTS

Hour	Winter	Summer
6 to 8 p.m.	330	222

Winter traffic 96% of summer traffic		
Expected Winter Accidents	0.96×222	=213
Accidents due to inadequate illumination	330–213	=117
	117/330	=35%

(c) P. S. Millar, Electrical Testing Laboratories, and O. H. Shaw, The New York Edison Company. Mean for 1930 and 1931, New York City.

FATAL TRAFFIC ACCIDENTS

Summer: May to August; Winter: November to February

Hour	Winter	Summer
6 to 8 p.m.	85	52
5 to 7 a.m.	16	10
8 p.m. to 5 a.m. and 7 a.m. to 6 p.m.	305	341
Factor to obtain expected Winter accidents from Summer accidents as determined by conditions other than lighting	305/341	=0.89
Expected Winter accidents	62×0.89	=56
Accidents to inadequate illumination	101–56	=45
	45/101	=44.5%

(d) R. E. Simpson, The Travellers Insurance Company. For 12-month period 1931; 46 cities distributed throughout the United States.

ALL TRAFFIC ACCIDENTS

Summer: May to August; Winter: October to January

Hour	Non-Fatal		Fatal	
	Winter	Summer	Winter	Summer
5 to 8 p.m.	20,664	9,516	794	366

15% of the accidents were on wet roads including both Summer and Winter. 3% were on icy roads. Based on these figures it is assumed that 10% of the accidents were due directly to wet or icy roads. Thus,

Expected Winter fatal accidents	366 + 36	=402
Fatal accidents due to inadequate illumination	794–402	=392
	392/794	=49%
Also expected Winter non-fatal accidents	9,516 + 951	=10,467
Non-fatal accidents due to inadequate illumtion	20,664 10,467	=10,177
Total accidents due to inadequate illumination	10,177 + 392	=10,569
	10,177/20,664	=49%
	10,569×$3000	=$31,707,000
Population of 46 cities	25,355,000	
	$31,707,000/25,355,000	=$1.25

per capita cost of Winter accidents due to lack of adequate illumination.

Based on these figures the corresponding cost for the whole United States is $201,534,000 or $1.68 per capita.

(e) Committee on Street Lighting of the Illuminating Engineering Society. New data, now first reported, for 12-month period 1931.

FATAL TRAFFIC ACCIDENTS

Hour	Winter	Summer	Ratio
3 to 5 p.m.	20	25	..
9 to 11 p.m.	27	23	..
Total	47	48	0.98
5.30 to 8.30 p.m.	72	33	2.18
Expected Winter accidents if same ratio held as for 3 to 5 and 9 to 11 periods	$33 \times 0.98 = 32$		
Accidents due to inadequate illumination	$72-32=40$ $40/72=55\%$		

SUMMARY OF DATA

Case	Date	Location	Per cent. accidents due to lack of illumination
(a)	1919–20	32 Cities	18
(b)	1929	New York, Pennsylvania, North Carolina, California	35
(c)	1930–31	New York City	45
(d)	1931	46 Cities	49
(e)	1931	12 Cities	55

These data indicate a notable increase in the percentage of accidents attributable to inadequate illumination, that is, to the difference between daylight and present street lighting, during the past decade. They also seem to show a continuing upward trend. It would seem that for future computations a round value of 50 per cent. would be conservative.

However, as stated in Section 1, it must be remembered that this is not a measure of the improvement to be expected by increasing from present illumination conditions to the highest practicable levels, but by increasing for present conditions to the equivalent of daylight, so far as the effect on accidents are concerned.

An approximate check on this figure of 50 per cent. may be obtained as follows: Table III in Section 5 gives an estimate of 20 per cent. of total traffic at night. As night traffic is certainly increasing this may be properly raised to 25 per cent.

If daylight conditions were assumed for the evening hours, evidently the accidents would be proportional to the traffic and there would result 25 per cent. of all accidents at night. If as a result of lack of illumination, the night accidents are doubled, for the same traffic, then for 75 day accidents there will be 50 night accidents, or the night accidents will be $50/125 = 40$ per cent. of all accidents, which agrees fairly well with the data of Table II in Section 5.

4. Comparison of Certain Streets Before and After Increase or Decrease in Lighting

The date here given call for no special comment. Attention is again called to the fact that this type of statistics gives the most definite indication of the saving in accidents due to the special case of change of lighting described, but that the number of reported cases is still too small to determine reliable ratios.

(a) Reported by Harrison, Haas & Reid, all of General Electric Company, Cleveland, Ohio.
Euclid Ave. and Woodland Ave. in 1923, well-lighted, one fatal accident on each. Superior Avenue and St. Clair Avenue same year, with poor lighting 8 and 7 accidents, respectively. During the day there were more traffic accidents on Euclid and Woodland than on the other two streets. (K. M. Reid).

(b) Reported by K. M. Reid. Same streets as in (a).
Lighting on Superior Avenue improved October 9, 1925.
January 1 to October 9, 1925, 5 fatal night accidents on Superior or at the rate of over 6 per year. (Compare number in (a).)
October 9, 1925 to October 9, 1926, 1 fatal accident.
October 9, 1926 to October 9, 1927, 3 fatal accidents.
Average for 2 years, 2 fatal accidents (1 victim intoxicated, 1 killed by hit-skip driver).
Lighting on St. Clair Avenue improved October 1, 1927.
For first and second 12-months periods preceding this date 6 fatal night accidents, each (compare number in (a).)
For the two years following October 1, 1927, 3 and 1 fatal accidents, respectively (3 intoxicated pedestrians and 1 killed by hit-skip driver).

(c) Reported by Wm. P. Bear, Pacific Gas and Electric Co., San Francisco, 3 miles of Bay Shore Highway within City Limits. Lighting improved on May 1, 1931.

All Traffic Accidents

	Total	Night	Day
Sept. 11, 1930 to May 1, 1931 (232 days)...	81	54	27
Sept. 11, 1931 to May 1, 1932 (232 days)...	67	32	35
Change................	14 decrease	22 decrease	8 increase
Per cent. change.........	17.3 "	41.0 "	29.7 "

Expected night accidents based on same increase as for day accidents 70
Accidents prevented by improved lighting........................ 38
Per cent. saving in accidents due to improved lighting............ 54.5

(d) Reported by L. J. Schenk, Public Lighting Commission, City of Detroit. Reduction of lighting in Detroit by elimination of 2000 lamps and reducing by 30 per cent. the output of the remainder.

FATAL ACCIDENTS, INCREASE OF 1932 OVER 1931

	Jan.	Feb.	March	April	Average
Total	14.6	33.3	10.5	5.3	15.9
Night	40.0	71.5	15.4	27.2	38.5

Ratio of night increase to total increase, due to decrease in lighting, 2.42.

Comparison of evening fatal accidents 'till midnight with total accidents is as follows:

RATIO OF EVENING TO TOTAL ACCIDENTS

	Jan.	Feb.	March	April
1931	46.4	38.0	47.4	47.4
1932	61.6	53.6	53.9	50.0
Increase in ratio 1932 over 1931	1.33	1.41	1.14	1.06

5. MISCELLANEOUS DATA

TABLE II.—PERCENTAGES OF TOTAL AND FATAL TRAFFIC ACCIDENTS WHICH OCCUR AT NIGHT

Authority	Date	Location	Per Cent. of Traffic Accidents at Night	
			Total	Fatal
Anderson & Haas	1919–20	32 Cities	30	37
D. M. Diggs—from records of Connecticut Motor Vehicle Dept	....	Connecticut	47	67
The Travelers Ins. Co.	....	The United States	..	47
N.Y. State Motor Bureau	1927	New York State	..	44
N.Y. State Motor Bureau	1930	New York State	..	50
N.Y. State Motor Bureau	1931	New York State	44	52
National Safety Council	1929	New York, Pennsylvania, N. Carolina, California	..	31
D. M. Diggs	1929	State of Delaware	44	52
W. A. F. Pyle	1930	State of Delaware	44	67
W. A. F. Pyle	1931	State of Delaware	45	..
National Safety Council	1931	The United States	39	..
Street Lighting Committee	1931	12 Cities	..	57

The relation of night to day traffic has been discussed by D. M. Diggs. He gives the data shown in Table III.

occur, only when the statistics include a large number of cases, as when they extend over several years,

TABLE III.—RELATION OF DAY TO NIGHT TRAFFIC

Authority	Night Traffic Per Cent. of Total
Maxwell Halsey, Traffic Engineer National Bureau Surety and Casualty Underwriter	10
Metropolitan Life Insurance Company	20
D. M. Diggs	20

TABLE IV.—RELATIVE INCREASE DAY AND NIGHT ACCIDENTS

Authority	Location	Years	Per Cent Increase	
			Day	Night
W. A. F. Pyle	State of Delaware	1930–31	3.4	10.5

or include a large number of communities.

6. COST OF ACCIDENTS SAVED BY GOOD LIGHTING

It is desired, on the basis of the data given in the preceding sections, to determine a figure such that when applied as a factor to the number of night accidents which take place under an existing inadequate system of street lighting, will give the smaller number which will occur in the same area under an improved and adequate system; or conversely the increased number of accidents to be expected when an adequate lighting system is reduced in an effort to economize.

As explained in Section 1, such figure can be expected to give a fairly close approximation to the number of accidents which actually

As stated in Section 3, the evidence is that about half of the present night accidents would not occur if illumination essentially equivalent to daylight could be provided during the night. A check on this figure is given in the data collected for 47 cities by R. E. Simpson. He shows a straight line relation between the evening fatal accidents (5 to 8 p.m.) and the per capita expenditures for lighting. The accident rate decreases from 4 to 2 per 100,000 as the per capita cost of lighting is increased from $1.00 to $2.00. That is, changing the lighting from an inadequate system at $1.00 per capita, to an adequate system at $2.00 per

capita, approximately halves the accident rate.

It appears certain that the street lighting could be made such that the night accident rate would be no higher than the day rate, perhaps even lower on account of the lower average traffic density. However, we cannot hope, in many cases, to duplicate daylight conditions, and thus we cannot hope, in general to obtain a 50 per cent. saving in night accidents. Without doubt the better the system of lighting, the greater the part of these accidents that will be saved, and in the case of such high intensity lighting as that used on the Cleveland thoroughfares, a saving of quite 50 per cent. may be hoped for. It becomes, therefore, a question as to how much will be spent in order to reduce the loss due to the excessive night accidents.

Assume, as above explained, that the kind of street lighting that has been defined as "adequate" will result in a saving of one-half the accidents attributable to absence of daylight illumination. From the data given in Table II of Section 5, it appears that close to 45 per cent. of all automobile accidents occur at night. This figure is taken slightly higher than those in the total accident column would justify, to compensate economically for the considerably more serious character of night accidents as seen in the last column of Table II. Thus, night accidents due to lack of illumination will be half of 45 per cent., or 22½ per cent., and of these, by the above assumption half of 22½, or 11¼ per cent. of all traffic accidents would be saved by change of present inadequate lighting to adequate lighting. Call this 11 per cent in round numbers. In the article by R. E. Simpson, referred to in Section 4, $2,500,000,000 is given as the annual cost of automobile accidents to the community. The determination of this amount is based on the property and personal injury premiums paid on insured cars, extended to all registered cars, plus the value of lives lost based on life expectancy. Data collected on the location of traffic accidents seem to indicate that about 70 per cent. occur in urban streets. This would give $1,700,000,000 as the share of the cost of such accidents chargeable to the cities.

A reduction of 11 per cent, therefore, in traffic accidents would mean a saving of $187,000,000 to the people of the United States. For a population of 120,000,000 this would give $156,000 per 100,000 of population, a convenient figure to apply to individual communities.

7. Effect of Good Lighting on Crime and the Cost of Crime

(a) Reported by Ward Harrison, General Electric Company.

Study of more than 1,000 crimes committed on streets or at the fronts of buildings in Cleveland in 1915 and 1916.

A high intensity lighting system was installed in the retail business district early in 1916, over an area of less than 10 per cent. of the city.

Ninety per cent. of all crimes studied were committed after dark.

Before improved lighting was installed 17 per cent. of all these crimes were committed in this district.

CRIMES FOR PERIOD OCTOBER TO DECEMBER

	Crimes in 1916 for 100 in 1915
Well-lighted district.......	92
Remainder of city.........	154

Decrease in crime in well-lighted district assumed due to improved lighting (154-92)/154=40%.

(b) Reported by K. M. Reid, General Electric Company, and F. M. Vicroy, Case School.

Study of effect of street lighting on street crime in Cleveland July 1, to December 31, 1931. The study included such crimes as automobile theft, hold-up of taxicab driver, entering buildings from the front, hold-ups with gun, strong-arm assault purse-snatching, and thefts from automobiles.

types quoted should be made available. However, as a conservative figure for the reduction in the number of crimes affected by street lighting, it seems that even these limited statistics would justify the use of 30 per cent.

Two hundred fifty million dollars as the annual cost to the country of burglary and theft, has been given on the authority of R. A. Algire, President of the National Surety Co. This figure has been used as a basis for estimating the saving in cost of crime by T. W. Rolph. While it is not just the figure that is needed, if other crimes not included are offset against those cases of theft and burglary that would not be affected by lighting, it may serve as a basis for computation. Thirty per cent. of this would give $75,000,000 as the saving to the country through crime prevention that should result from good street illumination.

	Crimes on adequately lighted streets			Crimes on inadequately lighted streets			Per cent. Decrease in crime on inadequately lighted streets
	Day	Night	Ratio	Day	Night	Ratio	
Business District	91	283	3.12	6	30	5.0	38*
Industrial and Warehouse	..	..	..	10	35	3.5	..
Thoroughfares	17	81	4.77	39	245	6.3	25
Residence	10	74	7.40	11	163	14.8	50

* Inadequately lighted streets too few to give much weight to this figure.

The amount of data here quoted is too limited to furnish any very exact figure upon the saving in the cost of crime that follows the raising of the street lighting to an adequate value, and much more data of both

8. CONCLUSION

The savings of $187,000,000 on accidents and $75,000,000 on crime

gives a total of $262,000,000 as the whole saving that would follow bringing all the street lighting of the country up to an adequate level. This gives $218,000 per 100,000 population.

A comparison of these figures with the cost of street lighting is interesting. While the cost of street lighting varies over a wide range, the average is about $1.20 per capita, or $120,000 per 100,000 population. It is estimated that $2.50 per capita, properly expended, would give any city an excellent system of lighting. Thus it appears that $130,000 per 100,000 population additional expenditure on street lighting should produce a profit on accident and crime prevention of some $88,000 also per 100,000 of population. This saving would indeed be still higher for city dwellers, as it has been credited to the whole population of the country.

It should be emphasized that these figures deal only with the two important elements of saving, accident and crime prevention. Complete figures would include also many indefinite, but by no means negligible, items, such as higher safe traffic speed with consequent saving of time and increased usefulness of street area at night, transfer of traffic from day to night, thus increasing the street area per car during the day; increase in business through greater night enjoyment of the well-lighted streets; facilitation of fire department runs, saving in cost of gasoline used for bright automobile headlights. Further, this report has nothing to say of the many personal and civic advantages that come to the citizens of a well-lighted community.

Luminous Gas Lamps

By Geo. G. Cousins, Illumination Laboratory, H.E.P.C. of Ont.

MUCH has appeared in print during the past year or so regarding the luminous gas lamps, erroneously classified as neon. The interest aroused is largely due to the fact that for years we have been told that there are potential possibilities of much higher efficiencies than those of incandescent solids of which the tungsten lamp is the outstanding example.

With the appearance of luminous gas light sources, there is a natural tendency to assume that the long-expected end has been achieved. The following is a brief review of the status of luminous gas light sources that have reached the commercial stage. The most convenient way of presenting the new lamps is to compare them with the lamps in common use, the tungsten lamps.

There are certain inherent differences between gaseous lamps and tungsten lamps that fit each to particular fields of application. The gaseous lamp is a light source of extended area suitable for broad distributions of illumination and not subject to accurate control such as is easily possible with tungsten lamps.

Gaseous lamps are of very pronounced color and this places a limitation on their applications. They are also at this time, commercially practicable only in large sizes. The important matter of efficiency must be considered with respect to the importance of color. Efficiency figures should be based upon the total current taken from the line which will include power lost in the accessories which are necessary with these lamps.

There is on the market a combination of mercury-vapor and neon tubes producing a reputed white light. This may be accepted as white where a standard white is not necessary although it appears a rather bluish white.

The spectra of luminous gases are composed of lines of color with gaps between while the spectrum of tungsten lamp light is continuous, that is, all the colors from violet to red are present. On account of this, tungsten light filtered to produce north-sky white is a reliable unit for the most accurate discrimination of color, whereas the apparently same white produced by luminous gases may show some colors markedly different. It must not be assumed, therefore, that because a combination of luminous gases appears to be of north-sky quality that it possesses the required characteristics for color matching, it may be suitable for some colors and not for others. The over-all efficiency of this unit is slightly less than that of the corresponding size of tungsten lamp (750 watts) in an extensive reflector. However, in cases where whiteness of light is of particular value, this unit may be considered as having a very high efficiency as compared to that of tungsten lamp light if it were necessary to produce the same, or nearly the same, color by filtering out the undesirable colors. The bluish white is suitable for industrial and commercial interiors and many stores.

Light sources of this type are particularly well suited to cove lighting and lighting built in to architectural details, such as pilasters and cornices. When used behind moulded glass, the colored shadows on the surface configurations produce very beautiful effects.

So far, gaseous tube lamps are not economical except in the large sizes and there appears to be no hope that in the near future they will be available in sizes suitable for the illumination of small interiors.

In places where people gather for recreation or relaxation, such as homes, concert halls, clubs and so forth, a warm color is very much to be preferred and is in fact, essential. There is not, at present, a gaseous lamp that fulfils this requirement. The sodium lamp, although of a yellow color, produces monochromatic light and the distortion of colors, under this light is as objectionable as that caused by mercury-vapor. Human skin appears of a terribly ghastly hue. Sodium light is totally unsuited to such a purpose.

The sodium light is the most efficient of any produced up to the present time. An installation of street lighting in Holland has been in use for some months. The General

Electric Co., also put up a demonstration installation at the Lynn works and at Swampscott, Mass. The over-all efficiency of the units is 40-50 lumens per watt, which is twice that of the larger general service tungsten lamps. The tube containing the sodium is enclosed in a surrounding tube of larger size and the space between is evacuated so as to conserve the heat in the sodium filled tube. There is a very large field of application for sodium lamps on highways and open spaces where the color is not important.

The foregoing discussion is based upon those applications of light where illumination of areas is the end sought. In the field of decoration or advertising where the light source itself is the main object, the situation is quite different. In this case, color itself is generally a valuable feature, and it does not matter whether the color is monochromatic or not. When colored light is produced by tungsten lamps all but the required color is screened out, consequently the undesired colors are wasted. Each gas when rendered luminous by the passage of electric current has its own characteristic color and this is produced at a higher efficiency than the same colors produced by filtered tungsten light. The range of colors available by means of gaseous tube lamps includes pale blue, green, orange-red and pale pink.

In these days when architecture includes ornamentation by means of built-in lighting on the facades and other features of buildings there are endless possibilities for the use of gaseous tube lamps. The fact that they are lines of light (that may be straight or curved) is a decided advantage. By combining tubes of different colors behind moulded glass panels and using them singly and in combination, strikingly beautiful effects may be produced.

The gaseous tube lamps have a disadvantage when used for spectacular lighting in that the light cannot be dimmed and blended as can light from tungsten lamps. The color changes must be sudden and this loses some of the charm of color.

Gaseous tube lamps possess many of the characteristics of arc lamps and are subject to many of the limitations of arc lamps as regards their application and control. They all require stabilizing devices for their operation and in this they lack the simplicity of tungsten lamp equipment.

It seems reasonable to expect that in the fields of application where they are specially suited they will largely supplant tungsten lamps and will probably open up new fields. It is apparent that a great deal of development is necessary before they will make serious inroads into the general illumination of interiors.

The Hazard of Electrical Economies

IN these days when practically every householder is seeking ways and means to economize, the amateur electrician has an added incentive, and cheap electrical devices that do not meet recognized standards are apparently being sold in increasing quantity. The effect upon a fire loss is clearly shown by the following report from one of our members covering fires occurring in a short period in a small suburban community.

Case No. 1. Mr. Tie. Mr. Tie's family loves comfort and convenience. Their home was equipped with an elaborate annunciator system with push buttons at the front, side and back doors, with other buttons in the dining room, living room and upstairs. Dry batteries furnished the power. There was evidently a high resistance short somewhere on the system, requiring battery replacements every two or three weeks. Batteries cost money. The chauffeur volunteered to end the trouble, and impressed by the economy drive of the head of the house, purchased, for 98 cents, a bell-ringing transformer that nobody had approved, and evidently not even the manufacturer, because no identification appeared thereon. Ordinary silk-covered lamp cord was used to connect the primary to the main 110-volt supply, but the connection was made on the live side of the fuse panel, so the primary of the poor, little 98-cent transformer had no safety valve between it and the power house. The high resistance short on the annunciator wiring was not detected nor cleared.

On Sunday morning the head of the house left home at 4.00 a.m. on a trout fishing expedition. At 7.20 a maid who slept out reported for work, and following her usual custom attempted to gain entrance to the kitchen door, but found the rear of the house a seething cauldron of flame. Her screams aroused a neighbour who turned in a fire alarm. Mrs. Tie evidently was aroused at the same time, and quite naturally came downstairs and proceeded to the back of the house to see what was burning. The firemen had great difficulty in rescuing her from the smoke and heat-filled dining room. An ambulance surgeon worked over her for more than half an hour before restoring life. Careful investigation indicated that the fire originated on the cellar ceiling at the place where the "economy" transformer had been installed.

Case No. 2. The monthly electric bills were high. The boy of the family had received some lessons in elementary electricity in high school. He determined to do his bit in the economy program. He rigged up a separate line on the outside of the meter to run the laundry equipment. The laundress attempted to put a heavy wet woollen blanket through the mangle. It stuck. She abandoned the operation but did not turn off the motor. At 2.30 a.m. the following morning, the milkman saw a vigorous blaze in the basement and turned in an alarm. The family was sound asleep upstairs. Damage was trifling, but circumstances might not always furnish a milkman to

discover the result of an unintelligent economy move.

Case No. 3. Not only are there fire hazards in economy moves, but unintelligent use of electricity for toys has proven to be a contributing factor. Last Christmas Santa Claus brought a little girl a toy electric iron and, up until the latter part of June, the little 8-year-old maiden had pressed dollies' clothes at least once a week with no result other than what the fond parents thought was educational amusement. One day last June little Evelyn plugged her toy electric iron into a baseboard receptacle and it did not heat up as usual. Just then a playmate called her outside to play on the lawn, and in disgust toward her educational toy she threw it down on her bed and proceeded to play, while the toy for some unknown reason proceeded to heat up. Their play was interrupted by dense smoke of the burning bed clothes emitting from the window. Again the prompt work of the municipal fire department minimized the loss. Electricity coming from the 110-volt supply sometimes proves to be a most hazardous thing when used and directed by not only the young, but those who are supposed to be of more mature age.

Case No. 4. A new bracket light was wanted. Of course, outlet box and BX were to be used. No open knob and tube work for this gentleman. He knew a thing or two, but the electricians charged such high prices that he would economize and do the work himself, but in fishing the BX in a wooden lath wall he miscalculated and the armoured part of the BX was short about 1½ inches, so that the armoured part of the BX was not locked into the iron box outlet, but the wires were long enough and the fact that they were exposed through the knockout hole did not mean anything to the amateur electrician. Had he not used standard BX and an iron outlet box? The BX was not fastened in the wall but had a free vertical play like an inverted pendulum of about 4 feet. The house was old and any movement on the second floor caused some vibration, and the rubber and braid insulation of the two wires rubbed against the edge of the knockout hole and a high resistance short was finally established. The fuses in the basement repeatedly blew and a crimped hairpin was substituted.

One evening when the little 9-year-old son, who was left alone for the evening, retired to his room he could not light the bracket light, but he did notice that the wall was uncomfortably hot. The little fellow telephoned the operator that "the wall in my bedroom is hot." In a few seconds a city fire company investigated and found the wooden lath emberized, just awaiting the admission of a sufficient supply of oxygen to turn this economy drive into perhaps a fatality.

It is probable that fires similar to those described are occurring throughout the United States, although owing to the general lack of facilities for the expert investigation and reporting of dwelling fires, the situation may not be generally realized. Electrical inspectors realize the seriousness of this hazard, but except in those communities where

the inspector has the power to prohibit the sale of substandard electrical equipment there is little that can be done except through public education and systematic reinspection.

The foregoing appeared as an editorial in The National Fire Protection Association Quarterly, and emphasizes the danger of the handy man making repairs to electrical equipment and of buying the cheapest material and equipment possible without regard to its construction. The Commission's Rules and Regulations provide for maximum safety to the public, but it is necessary that the public co-operate by exercising reasonable care in the use of appliances. Only approved material should be purchased; unapproved material is almost sure to be substandard.

Ingersoll Hydro Shop, one of the winning windows in the Hydro Lamp Window Dressing Contest.

Hydro-Electric Power Development in Canada

By T. H. Hogg, D. Eng., Chief Hydraulic Engineer, H.E.P.C. of Ont.

(Presented at the Semi-Annual Meeting of The American Society of Mechanical Engineers, Bigwin Inn, Muskoka, June 27th to July 1st, 1932.)

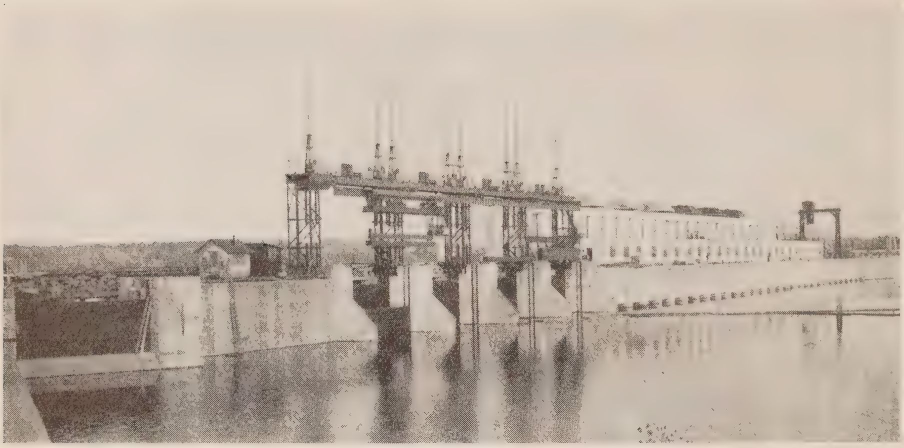
(*Continued from November*)

TYPICAL DEVELOPMENTS

It is not proposed to describe any of the recently constructed developments, except in so far as it is necessary to do so to explain those features that are unique or illustrate typical contemporary practice. No attempt can be made here to deal with all recent or current developments, and the discussion will be therefore limited to a few developments recently completed or at present under construction.

Beauharnois Development. This development, on the St. Lawrence River in Quebec, takes advantage of the difference of 85 ft. in level of Lakes St. Francis and St. Louis, two of the expanses on the river. The water supply for the power house is drawn through a power canal 15 miles long and 3,000 ft. wide, formed largely by dikes, the natural ground surface being below the Lake St. Francis level, except close to the intake. The power house is located across a portion of the lower end of the canal close to Lake St. Louis. Provision is made for the installation of twelve units of 53,000 h.p. each, and these, under the operating head of 80 ft., are of exceptional size. The units run at 75 r.p.m., and have a specific speed of 73. It is interesting to compare the turbines of this development with those at Cedars Rapids nearby—in their day the largest turbines built so far as physical dimensions were concerned. Those at Cedars have a capacity of 11,300 h.p. and operate at 54.3 r.p.m. under a head of 30 ft. Their specific speed is 83, and the runners are 16 ft. 2½ in. in diameter, as compared with 18 ft. for the Beauharnois units.

Chats Falls Development. This development is located on the Ottawa River, about 35 miles upstream from the city of Ottawa, and is connected by a 220 kv. transmission line over 200 miles long to the Niagara system of the Hydro-Electric Power Commission at Leaside. Four units are installed and operating, and four more are nearing completion. Two additional units will complete the installation. The plant operates under a head of 53 ft. The turbines have a rated capacity of 28,000 h.p. each at 125 r.p.m., and are of the propellor type, having a specific speed of 147. Units of this type have a high efficiency at or near maximum capacity which is not well sustained at part loads. They exceed turbines of the Kaplan type in maximum efficiency, but are, of course, much less efficient at part gates. Their installation in such plants as that at Chats Falls is



Sluice Gates and Headworks, Chats Falls Development on the Ottawa River. (Head water about 10 ft. below normal level.)

amply justified, since there are a large number of units in the plant, the minimum flow of the river is well sustained, and the plant is part of a large interconnected system. It is thus possible to operate units always at or near full gate, and thereby gain full advantage of the high efficiency of these turbines when so operated.

Alexander Power Development. This development on the Nipigon River came into service late in 1930. Three units are installed here, the turbines being rated at 18,000 h.p. under a head of 60 ft. Features of interest in connection with the development are the large semi-hydraulic earth-fill dam and the elimination of sluiceways of any kind for the discharge of flood water. A concrete spillwall, 525 ft. in length has a discharging capacity in excess of the maximum river flow anticipated.

A feature of this plant, seen also in the Chats Falls Development on the Ottawa River, is the elimination of the headworks superstructure. The headgate hoists are protected by a low housing. Openings in the headworks deck, to allow the placing or removal of emergency gates and racks, are protected by close-fitting removable plant covers, and a locomotive crane, available for service elsewhere also, is provided for the service usually performed by a travelling crane. Winter-weather conditions at this plant are usually severe, temperatures 20 to 40 deg. below zero being frequently experienced. To cope with these low temperatures, provision is made for the admission of warm air from the power house to the space below the headwork deck. The two winters during which the plant has operated have been milder than usual and no ice trouble has been experienced, but the weather was sufficiently severe to test and prove the efficacy of the protection provided.

Complete plant tests were made here in March, 1931, turbines, generators, and governors all being investigated. The turbine tests were carried out by the Gibson method. Conditions were far from ideal for a

test of this type, but the results obtained were consistent and satisfactory, and indicate that the method is applicable in cases where only very short supply pipes are available.

Each turbine receives its water supply from a concrete scroll case fed by two concrete supply pipes 18 ft. wide at the intake and of a height varying from 19 to 12 ft. Connections were installed at the time of construction to permit tests by the Gibson method to be carried out. These connections were so arranged that separate measurements of water would be made in each of the supply pipes. This necessitated the use of separate systems of piping from connections made at upstream and downstream stations in each supply pipe, and the use of two Gibson instruments. The supply pipes are unusually short for a test of this kind. The distance between the upstream and downstream test taps was only 22 ft., or only slightly more than the width of the pipe; the ratio of length of pipe used to diameter is believed to be less than in any earlier successful Gibson test. Every effort was made to overcome the difficulties imposed by the usual conditions. All instruments, including instrument transformers, were calibrated.

Complete tests were made of all three units in the plant, and the results obtained from the separate units were so similar that only a single composite curve was plotted. The power-discharge and turbine-efficiency curves are shown in Fig. 2, the test points from each unit being distinguished by different markings. It will be observed that close agreement exists except at low discharges. Here

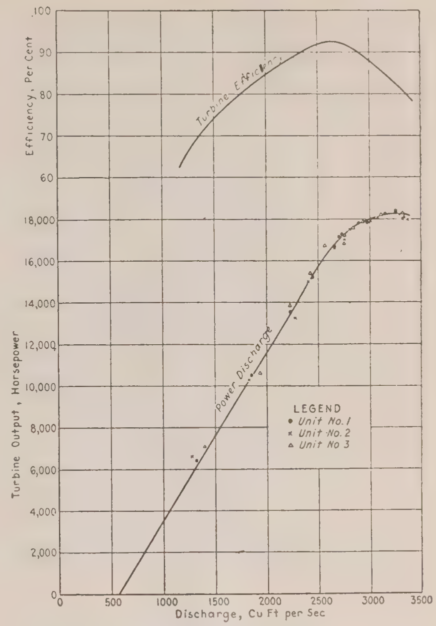


Fig. 2.—Power-discharge and turbine-efficiency curves of units of the Alexander Power Development. (Head, 60 ft. Data from test made in March, 1931).

the Gibson diagram was so small that minor errors in scaling its area would result in appreciable percentage differences in the computed discharge. This is only true over a small range of low discharges; very close agreement between results from different units will be observed in the region of maximum efficiency. The maximum turbine efficiency shown by the tests was 92.8 per cent.

It has been stated above that separate measurements were made of discharge in each of the supply pipes. The measured results for units 1 and 2 are shown in Figs. 3 and 4, respectively. It will be seen that the discharge through each supply pipe is very much the same at all gate

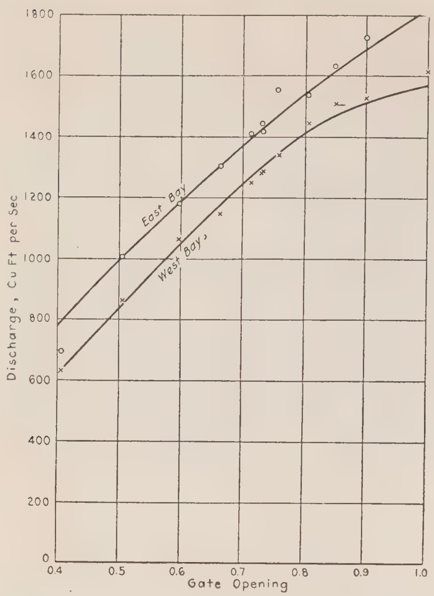


Fig. 3.—Gate discharge for each Bay of Unit No. 1, Alexander Power Development.
(Head, 60 ft. Data from test made in March, 1931).

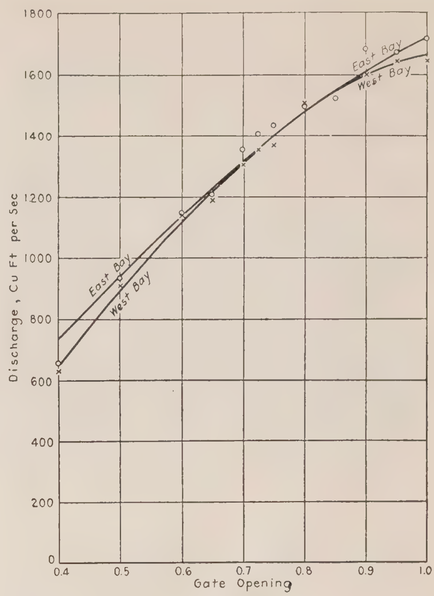


Fig. 4.—Gate discharge for each Bay of Unit No. 2, Alexander Power Development.
(Head, 60 ft. Data from test made in March, 1931).

openings for unit No. 2, but differs materially for the supply pipes in unit No. 1. The lower discharge through the west supply pipe of unit No. 1 is due to a very slight increase in resistance, introduced by a projecting canal wall near the intake. The unbalanced discharge had no apparent effect on the efficiency of the unit.

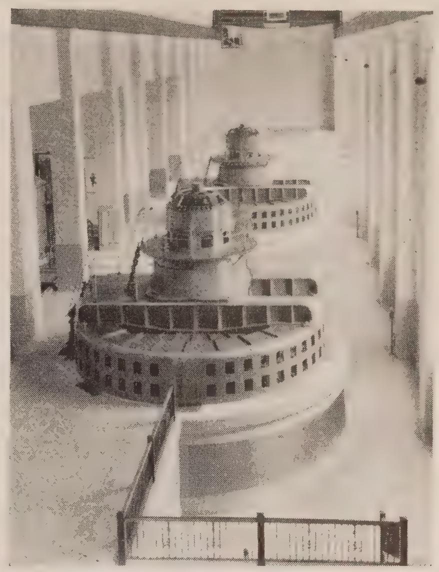
Chute a Caron Development. The Saguenay River has characteristics similar to those of the Nipigon and Ottawa. Lake St. John, on this river, having an area of 350 square miles in its natural state, provided a high degree of regulation, the ratio of high to minimum flow being about 16. The lake is now regulated by dams at the outlet. The Chute a Caron Development, on this river, illustrates a tendency toward units of very large capacity. The head developed is 151 ft., and the units have a capacity of 65,000 h.p. under this head at 120 r.p.m. The scroll cases are of heavy steel-plate construction, varying from 1¼ in. to ¾ in. in minimum thickness, with an inlet diameter of 17 ft. 6 in. They are completely enclosed in concrete.

Construction difficulties in connection with this development were unusually great. At the dam site, the Saguenay flows in a narrow gorge, where the depth of water was 65 ft. in times of lowest flow. Control of water during construction involved the diversion of the whole river flow through an artificial channel.

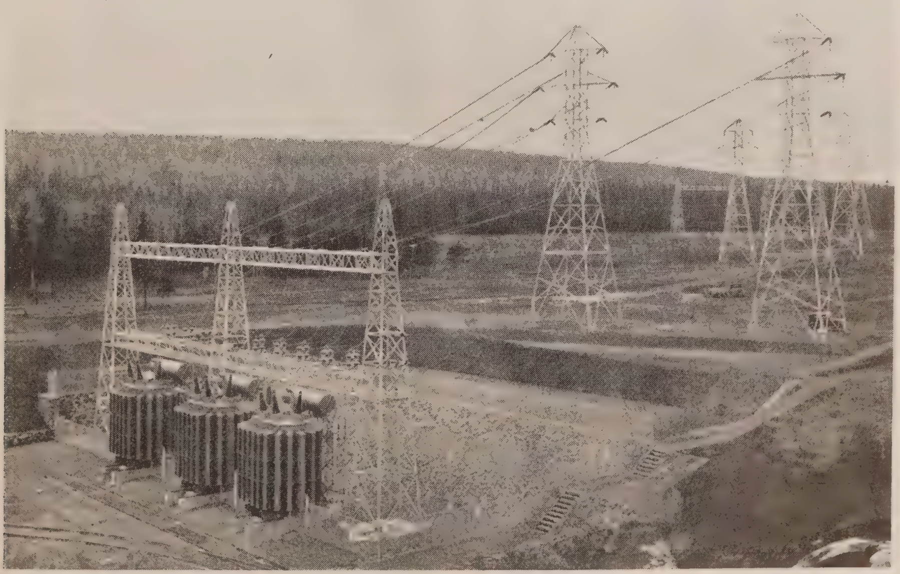
Winnipeg River Developments. On that part of the Winnipeg River

between Point du Bois and Great Falls, a distance of about fifty miles, there are now four major power developments, all of which contribute to the power requirements of the city of Winnipeg and the surrounding district. The river flows into Lake Winnipeg, about seventy miles northeast of the city of Winnipeg, and drains large areas in Ontario, Manitoba, and Minnesota. Included in its tributary areas are Lake of the Woods Rainy Lake, and Lac Seul, all of which are regulated.

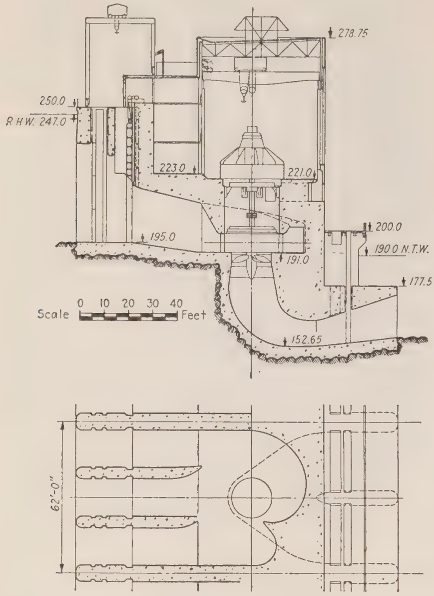
The four developments that are referred to above are the two municipally owned plants of the Winnipeg Hydro-Electric System at Point du Bois and Slave Falls, the 168,000 h.p. development of the Manitoba Power Company at Great Falls, and the 225,000 h.p. development of the



Interior of Generating Station, Slave Falls Development.
(Note compact arrangement and absence of auxiliary apparatus.)



Outdoor Transformer and Switching Station, Alexander Power Development on the Nipigon River.



Cross-sections of Power house of Chats Falls Development on the Ottawa River.

Northwestern Power Company at Seven Sisters Falls.

The progress in the development of the hydraulic turbine and in power-house layout is exemplified by these plants. The Point du Bois plant is equipped with sixteen units, the first of which, installed in 1911, was of Swedish design, with a horizontal double runner, and of 5,200 h.p. capacity. The Great Falls plant contains 28,000 h.p. propeller units having a specific speed of 128 and operating under a head of 56 ft., the first being installed in 1922. The selection of such units at that time was decidedly bold. The later plants at Slave Falls and Seven Sisters also have propeller units, but of higher specific speed, and those at Seven Sisters Falls are of unusual capacity and head for this type, viz., 37,500 h.p. under a head of 66 ft. The Slave Falls plant exemplifies to a wonderful degree simplicity of design, as will be seen from the illustration shown of the generator room.

Power-House Layout

The trend toward simplification in design and layout, already referred to, has extended in all directions. Many stations now contain nothing but low-voltage equipment, the transformation and high-tension switching being separated from the generating portion of the development. The transformation and high-tension switching is, of course, unhoused in such cases, even in situations where very severe winter conditions are experienced. This arrangement is to be found most frequently at low- and medium-head developments. When, on account of increased head, greater space is necessary between headworks and generator room to provide stability or satisfactory water passages to the turbines, the high-tension equipment is frequently located to take advantage of the foundation provided by the part of the substructure occupying this space.

It is quite evident, from a comparison of old and recent power-house cross-sections, that a reduction has been effected in power-house width. The interior view of the Slave Falls station and the cross-section of the Chats Falls power house both show this reduced width. The latter cross section also shows the long horizontal section of draft tube extending far beyond the down-stream power-house wall.

Some Observations on Paint and Painting from a User's Viewpoint

By T. H. Chisholm, Chemist, H.E.P.C., of Ont.

(Presented to Toronto Paint and Varnish Club, September, 1932.)

IN testing paints from a user's viewpoint, it is necessary to have a thorough understanding of the surface to be painted and the nature of the exposure. Keeping these points in mind the tests are simply comparative tests with the materials recommended by the different paint manufacturers unless you are purchasing to a definite specification.

Before making further remarks on this subject, I would like to make it plain that any statements I may make are the opinions of one man based on tests and field observations. These opinions may not be facts, and sometimes we change our opinion.

An outline of the procedure followed by the Hydro-Electric Power Commission in selecting structural steel paints, which is in general the same as used for other lines although the nature of the particular tests may vary, is to request the manufacturers to submit a sample of paint which they would recommend for the particular exposure. A small panel is painted and given an accelerated test in our weather-ometer. If it does not make a fair showing on this test, the sample is discarded and the brand is listed in our records as not being suitable for the particular exposure. If the sample makes a fair showing on the accelerated test, the percentage pigment, vehicle, volatile in vehicle, principal ingredients in pigment and the pounds per gallon are determined. These tests are made so that the paint may be definitely identified, should purchases of this brand be made at some later date. Large panels are then painted, making special notes on its brushing, hiding and general workability, and then exposed under conditions similar to what the paint is likely to be subjected to in practice. If the paint appears suitable after these tests, it is tentatively approved. If, however, the paint is purchased for some job, the engineer in charge is requested to pay particular attention to field application and report to us in detail as to general workability. In many cases a representative from the laboratory will visit the job while the work is under way, to get first hand information. If the paint is satisfactory on the field tests it is listed as an approved paint.

Records are kept of the paint used on important structures, along with the date they were painted. Inspections of the painted surface are made from time to time and the data are used in tying up laboratory work with field practice, as well as for estimating the ultimate cost of a job.

The application and service required of a paint is important, but is too big a subject to properly discuss at a meeting of this kind.

However, it might be of interest to outline some of our conclusions on general structural steel paints, and how we arrived at these conclusions. For instance, the much talked-of "Properly Balanced Paint Formula" is important. Now, I am not in a position to state what a properly balanced paint formula is, but the relation of pigment to non-volatile vehicle and the film thickness of a coat of paint appears worthy of consideration.

Some time ago, we selected what we considered to be a good grade of graphite paint and calculated the weight of paint necessary to cover a given surface and have a definite film thickness after the volatile had evaporated from the film, no corrections being made for shrinkage of fixed oils, etc. A number of small panels were prepared and a weighed film of paint applied which would give a pre-arranged film thickness when dry. The film thickness of the first panel was calculated to be ¾ of a mil, second, one mil, third, 1½ mils, fourth, 2 mils, fifth, 2½ mils, sixth, 3 mils, seventh, 4 mils and eighth, 5 mils. After the paint was applied the panels were exposed in a vertical position on the roof of the laboratory for observation. From this test it would appear that the film thickness should be over 2 mils, and preferably about 3 mils for one coat work.

Tests were also made using two graphite paints each containing the same amount of pigment per gallon, but one contained only five per cent. volatile in the vehicle while the other contained twenty-eight per cent. volatile in the vehicle. Panels were prepared with each paint so that the film thickness of the dried film would be the same in each case (about 2½ mils). The panels were then exposed in our weather-ometer and both paints gave fair service, but when the test was discontinued the one containing the high volatile had given the better protection.

Two paints were prepared similar to those already referred to but the pigment in the low volatile paint was increased until the relation of pigment to non-volatile vehicle was the same in each paint. Panels were then painted with each of the paints at a spreading rate of 625 square feet per Imperial gallon and subjected to weather-ometer tests. At the end of this test the low volatile paint was giving the best protection.

Assuming the data obtained on these tests are correct it would indicate the importance of having the proper amount of pigment to fixed oils for maximum protection and the proper amount of volatile material to give the desired film thickness under practical working conditions.

In general, the color of a priming paint is not important. However, we have been criticized by paint manufacturers for objecting to the so-called blue lead primers especially when it is intended to finish with aluminum paint. Some years ago, we painted a few miles of transmission line towers with blue lead primer, and a chocolate colored red lead base primer and a finish coat of an aluminum paint. On the completion of this job, a close examination showed that there were numerous misses with the aluminum paint over the blue lead but practically none where the aluminum paint was applied over

the chocolate colored primer. This was due to the misses over the blue lead not being noticeable a short distance away, but the misses over the chocolate colored primer were very noticeable and the workmen did not leave them. It was considered necessary to paint the towers primed with blue lead this summer due to failure of the portions not being coated with the aluminum paint.

Another interesting point drawn to our attention when priming with a straight red lead, is that on structures such as towers, the reflection of the sun on the bright red dazzles the workmen's eyes and slackens the speed with which the work is carried on, as well as being aggravating to the workmen.

The question of spray painting has received some attention. Although considerable can be said for this method of applying paint, we prefer brush painting. Many engineers are of the opinion that when using the spray, the paint is driven into the rust pits and around joints and rivet heads, but our observations show that this is not always the case. If the paint gun was always held straight or at the proper angle this might be true, but we have found that when it is used by the average workmen there are more spots around rivet heads, joints and deep pits that are bridged over. Our practice with large tanks, etc., where the spray is used for speed is to have a man go over all joints and rivet heads with a brush before the paint dries.

On surfaces badly pitted, it is good practice to apply the primer first with a circular motion of the brush to make sure it is worked well into the bottom of the pits and then laid off in the usual manner. A structure exposed to ordinary exterior conditions can be protected for seven to ten years if properly painted with good paints. If, however, the work is carelessly done and the primer not worked well into the pits, or little air gaps are formed under the paint film at the joints or around rivets, corrosion will likely start and the paint film will then break at these points in about eighteen months.

There are a great many different ideas as to what materials make good primers. Some of our most satisfactory jobs have been obtained with straight red lead primers. However, a good grade of red lead is expensive, and we find that very few paint firms make a real good red lead paint. The so-called chromate primers appear to be quite popular at present, and we find many of them very good. In many cases the tendency is for the manufacturer to almost forget the chromates. Although the basic chromates may retard rusting, the acid chromates appear to excite rusting. If this observation is correct, one can see the mistake it would be to use such a paint where there is danger of acid fumes such as sulphur dioxide to any great degree.

We are quite often asked why we do not approve certain iron oxide primers as many users find them excellent. Our position with the straight iron oxide primers is that we cannot be sure of the service that they will give, for our results with them have been erratic. Therefore, we prefer not to use straight iron oxide primers although many of the

primers we do use contain considerable iron oxide.

The painting of galvanized surfaces is somewhat unsatisfactory when the paint is to be applied over new galvanizing. Many firms supply special primers for this work. Our practice is not to paint new galvanized iron until it has weathered considerably. If it is not convenient to wait for the surface to weather, we apply a wash of copper sulphate. We are not sure what should be the proper strength of the copper sulphate, but we use a much stronger solution than usually recommended, namely, 1½ lbs. of the crystals per gallon of water, and have had very good results. After the copper sulphate wash, we recommend a regular structural steel primer. The priming of galvanized surfaces is not as important as with black iron, but our tests indicate that better results are obtained by using the primer, and our experience does not support the theory that special galvanized iron primers are necessary, or give any better service than would be obtained by using any good primer suitable for black iron.

Structures totally immersed under water appears to be a problem to the paint manufacturers. We have a test rack in the Niagara River where paints for this exposure are tried out and to date have exposed some seventy-three different manufacturer's recommendations and the majority of samples failed to give protection for two years. Some asphalt paints or preparations and coal tar paints give fair protection, but we are still looking for a good under-water paint.

Considering the results we have had with under-water paints, and the rate of corrosion of structures under water, we believe in hard water it would be as economical not to paint at all if it was not for the portion exposed at the waterline where it is intermittently wet and dry.

Our observations on structural steel painting would indicate that when using a reasonably good grade of paints, the success or failure of the job depends on the preparation of the surface, and care in the application of the primer. The usual methods of preparing a surface are either by sand-blasting or steel brushing and the method most suitable will depend on the condition of the surface. For instance, if the surface has heavy scales of rust firmly attached, deep rust pits or a coating of mill scale on it, we believe the best practice is to have it sand-blasted, or if the structure is not assembled it might be more convenient to have it pickled. Sand-blasting has its drawbacks due to the very small pits that are formed, and special care must be taken to get the paint worked well into the bottom of the pits, and the primer should be applied the same day that the surface is sand-blasted. With pickling, one may not get the pitted surface, but if the salts formed from the pickling are not all washed from the surface they will set up corrosion under the paint film. When the surface is not coated with mill scale and has only a light rust coating, it can be put into first class condition by steel brushing which eliminates the formation of small pits or the deposits of salts on the surface.

Interior painting (which is chiefly

for decorative purposes), we find as with general structural steel painting that the success of the job depends a great deal on proper priming. Once a surface is primed the points that must be considered are the workability, color and appearance of the finish. Practically all the brands offered for this purpose will give a reasonable life but there is a great difference as to their general workability, hiding and general appearance.

As the nature of the walls in different buildings will vary considerably, a primer that is ideal for one job may not be as suitable on another. For example, a smooth putty coat plastered wall will offer different priming conditions than a rough float finish cement plaster applied on a tile wall. In the first case a flat or semi-gloss paint, heavily pigmentized will quite often give good service, and fair results can be obtained by a two-coat job. Such paints are not altogether satisfactory on the rough wall, as this surface is porous and the vehicle in the primer is absorbed into the wall and the pigment is deposited on the surface. When the second coat is applied, the vehicle may also be absorbed into the wall in spots leaving a dappled effect due to the primer not sealing. If the vehicle in the primer does not penetrate into the wall and the inner plaster is a little green, the moisture may work its way to the surface and attack the vehicle causing flaking at some later date. This flaking may not take place for some time after the paint has been applied and when it does, the original priming is the last thing suspected as being the cause.

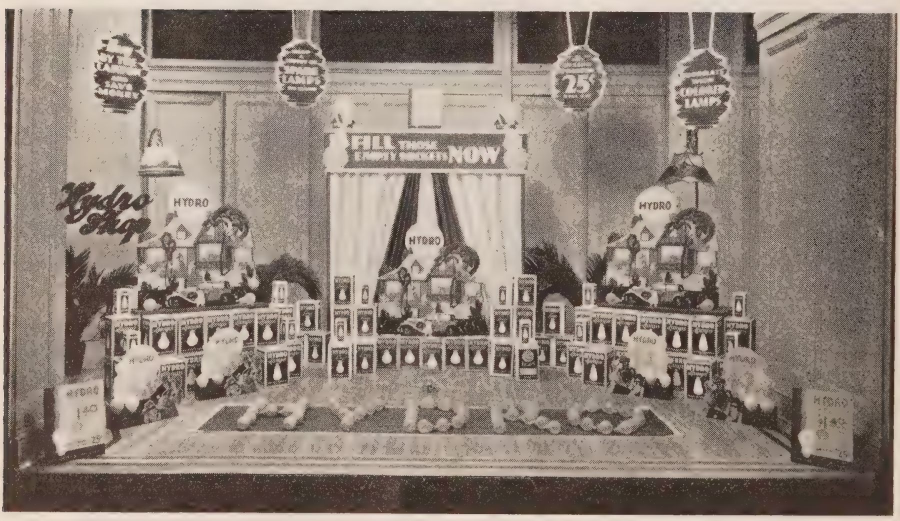
We do not favor flat priming coats, but like a primer with a long oil vehicle and one that not only seals the surface but penetrates well into the surface. If you get good penetration you are not likely to have trouble by alkali attacking the primer unless excessive water gets into the wall. If the oil penetrates well into the surface, the little moisture that is in the wall and saturated with alkali, does not get to the surface but it will attack the vehicle in the wall forming a soap which closes the pores, and the vehicle nearer the surface which bonds the coat of paint to the wall is not affected. I might offer a suggestion here that is frowned upon by maintenance engineers due to the extra cost and from reports I have had, laughed at by the paint manufacturers and that is, to apply a coat of linseed oil treated with a little drier to penetrate well into the surface.

If the surface has a trowelled hard finish the oil may be thinned with a little turpentine to insure good penetration. This coating is more as an assurance that the alkali in the concrete will not attack the paint film and takes the place of such treatments as zinc sulphate or magnesium-fluo-silicate washes. The same paints applied on concrete test panels have given a much longer life on a surface treated with linseed oil than a surface not treated, when exposed in a damp place.

With the newer finishes such as those of the Glyptal and Bakelite types our experience is limited and the results we have had are erratic. Some of these materials give excellent results on accelerated tests, and on a

few jobs where they have been used in the field, they look very promising. We have had samples of these paints supposed to be the same brand but obtained at different times in which the pounds per gallon, per cent. vehicle and volatile in vehicle was practically the same, but one checked badly after 250 hours in our weather-ometer while the other had not checked after 3000 hours. With results like these, we have been a little backward in recommending the use of such materials.

In conclusion, I might state that too much care cannot be taken in preparing the surface and applying the paint. Also, that the paint should be supplied by the manufacturer ready for application. We do not like the practice of having to add certain materials to the paint on the job, as much of our work is done by handy men. Even where master painters are doing the work each man appears to have a different idea as to the material and quantity necessary to make the paint work just right.



Hamilton Hydro Shop, another of the winning windows in the Hydro Lamp Window Dressing Contest.

Line Maintenance Under Difficulties

TO spend over sixteen hours in sub-zero weather, endeavouring to locate trouble on a transmission line, is all in the days' work for a line patrolman. Should it be necessary to tramp twenty-one miles along the right-of-way before the trouble is located is also part of the job, and should there be no broken road along the right-of-way, that also is accepted. In brief, such is the story of an incident in the work of Anton Ingard, Hydro Patrolman, on the line of the Howey Gold Mines, in the Patricia District.

Power for the Howey Mines, in the Red Lake district, is transmitted from the Commission's Ear Falls generating station over the Mining Company's 44 kv. line, a distance of 40½ miles. This line is built on a cleared right-of-way, through a bush and lake country, where transportation is generally by water or air, there being no roads in the district.

The accompanying illustrations showing the transmission line right-of-way were taken soon after construction was completed three years ago. Since then young tree growth has sprung up over the right-of-way, which has grown very fast. This adds considerably to the difficulty of patrolling the line, which is normally over very rough ground.

About ten o'clock on the morning of November 16, 1932, the generating station instruments indicated trouble on the line. Patrolman Ingard left the generating station at 12.20 p.m., another man following half an hour behind with a dog team and the

Howey Gold Mines line looking towards Red Lake.

Early winter scene along Howey Gold Mines line.

heavier tools on a sleigh. There had been some heavy snowfalls a couple of days before, which made travelling very difficult, twenty-two inches having fallen during November up to that time.

By eight o'clock in the evening Mr. Ingard had reached a point on the line eleven miles from the generating station. Here he waited for the man with the dog team, who arrived about an hour later. The dogs had played out so he had left them about three miles back. After resting for an hour, Mr. Ingard left the man there and went on alone. A little after midnight, Mr. Ingard had reached Trout River, sixteen and a half miles out. At 4.45 the next morning he arrived at a cabin at the Chukuni river crossing, twenty-one miles from his starting point. Here he reported back that all was clear so far and that there had been plenty of light for him to see all the insulators.

Men started out from the Howey Mine at about the same time as Mr. Ingard left, and arrived at a Patrolman's cabin at the Bug River, a distance of 7½ miles from the mine, where they stayed all night, and at eight o'clock next morning they continued their journey. At 2.10 in the afternoon they reported having found the trouble at a point about ten and a half miles from the Howey Mine. They went back about a mile to a supply depot to obtain spare parts, and repairs were completed and the line made alive again at 5.04 that afternoon. The weather was clear and cold, ranging from twenty below to twenty above zero.

Two years ago, on a case of line trouble, Patrolman Ingard went out fifteen miles and returned the same night. On this trip he found a large

spruce tree blown across the line, which he cleared before returning. This was during a blizzard when it was impossible to walk more than two miles in an hour or travel at night.

Light and the Evolution of Artificial Lighting

By F. S. Coates

LIGHT is incomparably the most important of all the agencies by which we gain our knowledge of the external universe. Other agencies, such as odours and sounds, tell us comparatively little; our knowledge is almost wholly the outcome of our visual perceptions. Sight is the most wonderful of all our senses, and sight, of course, is dependent on the presence of light. It is interesting to recall that at least one writer of acute intellect in ancient times held that it was something emanating from the eye, not something from without entering into it, that enabled us to perceive distant objects. That light is propagated in time cannot be inferred from ordinary observation because of the enormous speed at which it travels.

It was by celestial observations that the finite velocity of light was first revealed. This was done as long ago as in 1676 by Roemer, who showed that an inequality in the times of occurrence of the eclipses of Jupiter's satellites, which he had observed, was simply explicable on the supposition that light is propagated with a finite velocity. The mean motion of a satellite round the planet being accurately known, the times of successive eclipses can be calculated. We learn, therefore, that light takes eight minutes and a few seconds to travel over the distance from the earth to the sun, the velocity now being usually regarded as 186,000 miles per second.

It would be possible to write many paragraphs dealing with the constitution of light and of other phenomena of similar characteristics but which do not come within the scope of our powers of visual observation, but we will leave such fascinating fields to the scientist and turn our thoughts into historical channels considering the development of artificial lighting from the crude fire of dried vegetation of our prehistoric ancestors to the wonders of recent achievement in the application of light.

No doubt our early ancestors learned to control and maintain fires caused by the sun's rays, and with the discovery of the principle of heat by friction they would have become able to start up these fires for themselves.

The first lamp was evolved when some animal slain in the hunt was roasted over the camp fire. The bright flames produced when drops of fat fell prompted man to make saucer-like vessels of stone or clay and collect this animal fat for use as required.

Probably the first portable illuminant was the burning twig snatched from the camp fire, and this would be followed by the rush torchlight. The hollowed-out stones were later improved by the introduction of a small hole in the side through which a wick was passed. This type of lamp can be traced right through the Bronze Age. Then came the flare followed by the Flemish oil lamp. Later still came the solidification of the animal fat with a centre wick, which formed the more convenient candle. This was later known as the tallow dip. Then came the wax candle which gave off a brighter light.

When large quantities of petroleum were found in America in the middle of the eighteenth century, the mineral oil lamp was introduced but was not generally used until much later. Improvements were made in this lamp by the substitution of the round wick in place of the flat one, and later a glass chimney was added. These latter innovations enabled a more complete combustion to take place which resulted in a brighter flame.

Fires, candles, and oil lamps formed practically the sole means of artificial illumination until about a hundred years ago, and even to-day, of course, candles and oil lamps are still in constant use all over the world.

When gas lighting was introduced a great step was made in improving the convenience of artificial illumination, and it is recorded that gas was first used for lighting by the Chinese, who piped natural gas from their salt mines by means of hollow bamboo canes.

With the introduction of electricity the possibility of improving the convenience of artificial illumination was still further enlarged, and a great deal of activity was evinced amongst scientists in the early part of the nineteenth century in the production of means for providing electrical energy.

Sir Humphry Davy, in particular, demonstrated the electric arc, and showed that electricity could be made to heat metals to incandescence. It was shown that platinum was the only metal that would remain at white heat without rapidly oxidising, but there the matter ended for many years, for the cost of providing electrical energy was so enormous that no one seriously thought of making electric lamps.

Although it is only within the last fifty-five years that glow lamps have been constructed in such forms and with such qualities as to answer practical purposes, attempts to produce them cover a much longer period. The use of the electric arc as a light either for experimental work or for illumination, was a problem which engaged the attention of scientists during the first three-quarters of the nineteenth century. Primary batteries only, however, were available as a source of current energy, and although some excellent lamps were produced which worked well on battery circuits, their use was confined almost entirely to the lecture room and the laboratory

The earliest mention of the electric incandescent lamp that we know of was in the *Courier Belge* in 1836, and the article referred to safety lamps for miners, the solution pointed out being a carbon conductor electrically heated in a vacuum. Jobart, in Brussels, proposed in 1838 to make use of a

small carbon in a vacuum, and Grove in the first place suggested the use of platinum wire in this connection. In the year 1841, De Moleyns took out an English patent for his first electric lamp, and tried bringing to incandescence both platinum iridium and pure iridium. These experiments failed.

Sir Joseph Wilson Swan's first thoughts were drawn to the subject of electric lighting by a lecture delivered by Staite in 1845, when he was only 17 years of age. Three years later he obtained some beautifully thin and flexible strips and spirals of carbonized paper, from different kinds of paper and cardboard cut into strips and coiled into spiral form, and packed in a mass of powdered charcoal contained in a fireclay crucible and baked to a high temperature.

It is interesting to note that this method of carbonization was in itself technically new, and that carbon in this form and condition of thinness and flexibility was previously unknown. It is also noteworthy that this mode of carbonization ultimately became the general mode of procedure in the carbonization of filaments for electric lamps.

In 1859, Du Moncel, experimenting with carbon filaments made from cork and sheepskin, obtained some very fair results. Starr and King also invented an electric lamp about this time consisting of a carbon conductor in a vacuum.

In the year 1860 Swan made experiments with a glass bottle with a wide neck, closed with an india-rubber stopper, the conducting wires passing through this stopper and holding the carbon strip between their ends. The air was exhausted as completely as possible from the bottle by means of an ordinary air pump with pistons and barrels, but owing partly to there being some trace of air left in the bottle, and partly to the carbon becoming distorted under the action of unequal heating, this experiment failed.

Konn and others worked at the subject, producing lamps, some of which were simple whilst others were more or less elaborate.

The fact that at this time there was no practical way of getting a cheap supply of electric current to make electric lighting, whether by arc or by incandescence, a really practical proposition, was a circumstance which impeded and discouraged further progress.

After the invention of the mercury vacuum pump by Herman Sprengel in 1865, Swan resumed his experiments to produce a satisfactory electric lamp by means of an incandescent carbon in an evacuated glass container, but serious difficulties presented themselves in these early experiments by the rapid wearing away and consequent breaking of the incandescent carbon, and also the obscuration of the lamp bulb by a kind of black smoke, seemingly indicating that the carbon of the filament was volatilized under the enormous heat to which it was subjected. Further experiments showed that the better the vacuum the less blackening of the glass was experienced.

By the year 1877 dynamo-electric machines were made with ever-improving efficiency, and a point was reached when, for lighthouses, or streets, or large buildings, it could be

demonstrated that electric lighting was, by means of the arc, actually more economical than gas on a similar scale. Incidentally at this time there was a great slump in gas shares, and it is interesting to note that Dr. Van Welsbach introduced his famous gas mantle shortly after the advances made in the development of electric lighting by means of the arc and by incandescence.

Swan obtained his first really good results with thin straight rods of carbon, electrically heated to incandescence in a vacuum, in the year 1877.

Sawyer and Mann, in a patent taken out in 1878, endeavoured to get rid of the difficulty which previous experimenters had found due to gases occluded in the carbon filament, by raising the filament to a glowing temperature by means of an electrical current, and then allowing it to cool in nitrogen. Lane-Fox, also, in November, 1878, took out a patent for a glow lamp in which the carbon filament was made of a special kind of grass.

Swan proceeded to develop the manufacture of filaments of cotton yarn treated with sulphuric acid, which he called "parchmentised thread," and which when carbonised were strong and elastic. He also developed a new process of exhausting the bulb whilst passing a current of electricity through the filament.

At a meeting of the Newcastle-upon-Tyne Chemical Society held on December 18th, 1878, Swan exhibited an incandescent carbon lamp which consisted wholly of a glass bulb, pierced with two platinum wires, supporting between them a straight, thin carbon conductor. Similar lectures were given in the following year in other towns and it was clear that Swan had solved the problem.

It is interesting to note at this point that Edison in America, who had been experimenting in the production of a satisfactory electric incandescent lamp by means of a platinum filament, abandoned his attempts in this direction and concentrated on the carbon filament. He succeeded in producing lamps similar to Swan's and exhibited them at a public demonstration given on October 1st, 1879, ten months after Swan had first exhibited his first successful lamp. Edison's first successful cotton thread lamp burnt for 40 hours and he patented this lamp.

Towards the end of 1883 Swan devised a new method of filament manufacture which very soon superseded the parchmentised thread process. The patent specifications of this new method (Patent No. 5978, 1883) disclosed that nitro-cellulose dissolved in acetic acid was squirted through a small die into methylated spirit, so as to form a continuous thread of indefinite length. This thread, after being washed and denitrated with ammonium sulphide, was then cut and shaped to the desired length and form, and carbonised in the usual manner. Swan conceived an idea of producing threads of special fine ness, which were capable of being used in a textile way for the manufacture of a fabric, and some of these fine threads were crocheted by his wife into lace and used to make the border of small table mats and doyleys. A few of these articles were exhibited at the Inventions

Exhibition of 1885, under the description of "Artificial Silk". In this application of the squirted cellulose thread lay the germ of one of the most important inventions of modern times, the manufacture of Artifiical Silk.

Cragside, Rothbury, Northumberland, the beautiful home of Lord Armstrong was the first house in England (and presumably in the world) after the inventor's own to be fitted with Swan's lamps. The installation, which was completed in December, 1880, obtained water supply from a neighbouring brook to drive a 6 h.p. turbine and constituted the first hydro-electric generating plant in this country. The distance of the generating plant from the house was 1,500 yards, and the conducting wire was of copper, the size being No. 1 Birmingham wire gauge (approximately 0.07 square inch) so that the current had to pass through 3,000 yards of this wire to complete the circuit. The number of Swan's lamps installed in the house was 45, and each single lamp at that time was estimated to be equivalent to a duplex kerosene lamp well turned up, or the equivalent of 25 candles, so that the 6 h.p. in supporting 37 lamps gave an illuminating effect of 925 candles.

Other pioneer incandescent electric lighting installations followed and in June 1881, the "Inman Line" had one of their vessels, the City of Richmond, fitted out with the new lamps. A trial installation in the House of Commons about the same time also gave great satisfaction.

The systems and methods of wiring in these early days were, to say the least of it, somewhat precarious, and the fittings such as switches and attachments for holding the lamps were all of a most primitive and makeshift description. There was no attempt at protection in the way of fuses, and it can readily be imagined that the number of short circuits and other faults would give rise to considerable trepidation on the part of those responsible for the installations.

The light-giving efficiency of the carbon lamp was not very high, and in 1897 Nernst produced a lamp, the filament of which was composed of rare earth oxides. The light-emitting rod consisted of a mixture of highly refractory materials—mainly the oxides of thorium and zirconium—and since these are incombustible, the rod could be heated in air instead of being enclosed in a bulb from which all air had been excluded.

Many people thought that the Nernst lamp would speedily replace the carbon filament lamp, since the cost of operation for a given luminous output was approximately half that of the carbon lamp. There was, however, a serious difficulty. The lamp was complicated in construction and, therefore, costly to make. Its filament was extremely fragile, and the method of operation somewhat complex. At ordinary temperatures the burner would not conduct electricity freely, and before the lamp could be started the burner had to be raised to a high temperature. This involved the use of a heater consisting of a spiral of fine platinum wire wound on porcelain. Owing to the considerable length of platinum spiral required, the porcelain rod itself had to be made in the form of a spiral or arranged zig-zag fashion.

The Nernst lamp had another grave disadvantage, inasmuch that it had a comparatively large negative temperature coefficient; that is to say as the temperature of the filament increased its resistance was decreased, and there was, therefore, a tendency for the lamp to burn out very quickly on a momentary increase of voltage. It was for this purpose that a steadying resistance was included. This protective device had a large positive temperature coefficient, and took the form of fine iron wire spirals enclosed in a small bulb filled with hydrogen. When the switch was first closed, current did not pass through the glower, but through the arm of an electro magnet, and thence to the heater. After a while, approximately half a minute to one minute, the glower had acquired sufficient conductivity to take current large enough to operate the electro magnet which attracted its armature, thereby automatically disconnecting the heater.

These lamps proved of considerable use for some time for projection purposes, but because of their inability to light up immediately, and their general complicated construction, they did not in any way supplant the carbon lamp, and have now been superseded by more efficient light sources.

The history of the incandescent lamp has centred mainly around experiments on the filament, but it was not till 1898 that the Osmium lamp proved the first real rival of the carbon filament.

Then came the Tantalum lamp in 1903, followed by the Tungsten lamp in 1904. Tungsten has proved the most suitable filament material, and only in improved methods of manufacture has the filament been changed, whilst the gas-filled lamp represents a great advance in luminous efficiency.

The daylight lamp, too, provides a reliable substitute for average conditions during ordinary daylight. For such purposes as the grading of leather, surgical diagnosis, and the grading of flour and tobacco, these lamps have proved of enormous value. Owing to the absorption in the process of modifying the light quality, a considerably higher wattage lamp is necessary to give the same illumination as that obtained from a clear gas-filled lamp.

The history of the electric incandescent lamp has been one of continual improvement and experiment, whilst the introduction of Neon lighting, floodlighting and other recent developments indicate that new methods and new applications of artificial illumination are still being devised by man in a ceaseless flow of ideas and inventions.

—Distribution of Electricity

Association of Municipal Electrical Utilities

ELECTION BALLOT, 1933

The ballot for officers of The Association of Municipal Electrical Utilities for the year 1933 will show the following names:

President—T. W. Brackinreid,
Port Arthur, (Accl.)

Vice-President—W. R. Catton,
Brantford
D. B. McColl,
Walkerville

Secretary—S. R. A. Clement,
H.E.P.C. of Ont.,
Toronto. (Accl.)

Treasurer—H. T. Macdonald,
H.E.P.C., of Ont.,
Toronto

D. J. McAuley,
H.E.P.C. of Ont.,
Toronto

Directors—(from the membership at large.)

E. V. Buchanan, London
R. L. Dobbin, Peterboro.
O. M. Perry, Windsor.
O. H. Scott, Belleville.
E. I. Sifton, Hamilton.
E. J. Stapleton, Collingwood.

District Directors:—

Niagara District—
R. S. Reynolds, Chatham.
H. F. Shearer, Welland.

Central District—
G. E. Chase, Bowmanville.
C. A. Walters, Napanee.

Georgian Bay District—
R. S. King, Midland.
W. W. Marshall, Orangeville.

Eastern District—
M. W. Rogers, Carleton Place.
J. H. Ross, Winchester.

Northern District—
C. J. Moors, Fort William.
R. H. Staford, North Bay.

Ballots will be distributed during the morning of the first day of the convention, January 24, 1933, and the ballot box closed immediately after the opening of the afternoon session on that day. Results of the election will be announced before the closing of that session.

Belleville Hydro Shop, also a winning window in the Hydro Lamp Window Dressing Contest.

Index to Volume XIX

Greetings

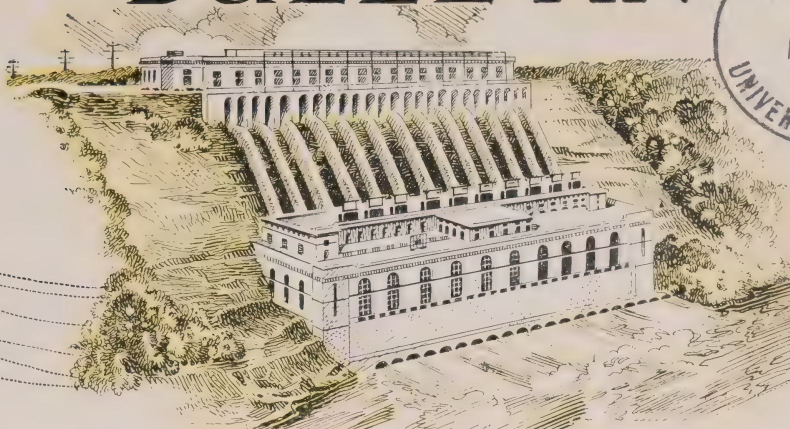
The Season's Greetings to All

WE thank you for the patronage we have received from All Hydro Municipalities during the past year and extend to the officials of All Hydro Systems our Heartiest Wishes for a very Merry Christmas and a Happy and Prosperous New Year.

Sales Department

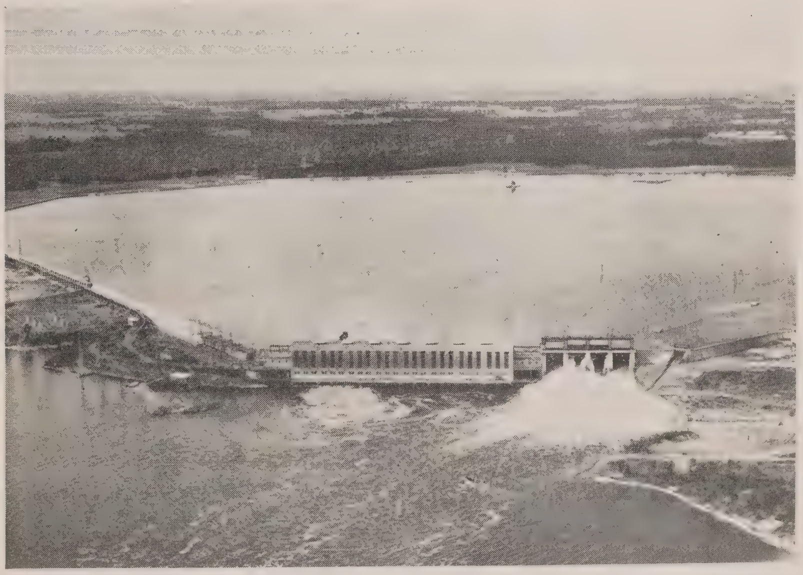
Hydro-Electric Power Commission of Ontario

THE BULLETIN



Vol. XX No. 1 JANUARY, 1933

Hydro-Electric Power Commission of Ontario



Chats Falls Development on the Ottawa River.

HYDRO MUNICIPALITIES

(Populations shown are from the last government report excepting where more recent figures have been furnished by the municipalities.)

EASTERN SYSTEM

Alexandria	2,370
Apple Hill	350
Arnprior	4,072
Athens	614
Bath	289
Belleville	13,914
Bloomfield	637
Bowmanville	3,604
Braeside	550
Brighton	1,343
Brockville	9,432
Cardinal	1,249
Carleton Place	4,278
Chesterville	1,000
Cobourg	5,619
Colborne	965
Deseronto	1,331
Finch	365
Hastings	656
Havelock	1,142
Kemptville	1,227
Kingston	22,368
Lakefield	1,428
Lanark	592
Lancaster	560
Lindsay	7,161
Madoc	1,019
Marmora	1,013
Martintown	357
Maxville	742
Millbrook	714
Napanee	2,984
Newcastle	590
Newburgh	433
Norwood	756
Omemee	489
Orono	700
Oshawa	25,550
Ottawa	130,617
Perth	3,762
Peterboro	22,798
Picton	3,146
Port Hope	4,415
Portsmouth	679
Prescott	3,078
Richmond	367
Russell	500
Smith's Falls	7,452
Stirling	822
Trenton	5,775
Tweed	1,206
Warkworth	500
Wellington	900
Westport	635
Whitby	5,463
Williamsburg	200
Winchester	970
Total	315,737

GEORGIAN BAY SYSTEM

Alliston	1,364
Arthur	954
Bala	336
Barrie	7,166
Beaverton	988
Beeton	561
Bradford	933
Brechin	255
Cannington	849
Chatsworth	251
Chesley	1,702
Coldwater	563
Collingwood	6,027
Cookstown	635
Creemore	598
Dundalk	659
Durham	1,744
Elmvale	600
Elmwood	350
Flesherton	448
Grand Valley	590
Gravenhurst	1,822
Hanover	3,102
Hepworth	327
Holstein	285
Horning's Mills	350
Huntsville	2,903
Kincardine	2,511
Kirkfield	138
Lucknow	1,115
Markdale	812
McTier	450
Meaford	2,708
Midland	7,116
Mount Forest	1,888
Neustadt	460
Orangeville	2,772
Owen Sound	12,778
Paisley	716
Penetanguishene	3,767
Port Carling	439
Port Elgin	1,203
Port McNicholl	825
Port Perry	1,288
Priceville	
Ripley	410
Shelburne	1,138
Southampton	1,700
Stayner	949
Sunderland	570
Tara	455
Teeswater	835
Thornton	200
Tottenham	538
Uxbridge	1,482
Victoria Harbor	950
Walkerton	2,280
Waubaushene	600
Wiarton	1,880
Windermere	124
Wingham	2,229
Woodville	403
Total	94,083

NIAGARA SYSTEM

Acton	1,951
Agincourt	612
Ailsa Craig	516
Alvinston	657
Amherstburg	3,083
Ancaster Twp.	3,119
Arkona	383
Aurora	2,623
Aylmer	1,996
Ayr	776
Baden	710
Beachville	503
Beamsville	1,185
Belle River	715
Blenheim	1,630
Blyth	621
Bolton	609
Bothwell	575
Brampton	5,137
Brantford	32,786
Brantford Twp.	7,595
Brigden	400
Bridgeport	500
Bronte	400
Brussels	725
Burford	700
Burgessville	300
Burlington	3,403
Caledonia	1,456
Campbellville	200
Cayuga	661
Chatham	16,441
Chippawa	1,222
Clifford	496
Clinton	1,911
Comber	800
Cottam	333
Courtright	370

THE
BULLETIN

Published by
HYDRO-ELECTRIC POWER COMMISSION
of Ontario

190 University Ave.
Toronto

Subscription Price $2.00
Per Year

Hydro-Electric Progress in Canada in 1932

WATER power development in Canada during 1932 was confined to undertakings already in course of construction at the beginning of the year. No new works of magnitude were initiated. This is disclosed in the annual review of hydro-electric progress prepared by the Dominion Water Power and Hydrometric Bureau of the Department of the Interior which shows that during 1932 water wheels or turbines actually installed and brought into operation resulted in the net addition of 378,923 horsepower to the Dominion's total, bringing it to a figure of 7,045,260 horsepower. Construction is also continuing upon several large undertakings which will increase the total in 1933 and subsequent years.

The programme of water power construction that is now approaching completion had its origin some three or four years ago before world-wide economic disturbances brought about an almost universal arrest of industrial expansion. Up to the end of 1929 the production of electric energy in Canada kept pace with the increase in installed capacity. Subsequently, however, depressed industrial conditions resulted in a falling off of the demand which reached its greatest intensity in mid-1931. More stable conditions now appear to have been established since the figures for the first ten months of 1932 indicate that electric energy produced for use in Canada is practically the same as for the corresponding period in 1931—an encouraging feature being that in August, September and October, the last three months for which statistics are available, an increase has been recorded. The reduction in total electric-energy production during the present year is almost entirely accounted for by the loss of production for export. For the first ten months of the year the export has been almost forty-six per cent. less than for the same period in 1931. So far then as the situation within Canada is concerned statistical records indicate that electric production is again increasing. What the rate of increase may be in the immediate future is very difficult

CONTENTS

Vol. XX No. 1
January, 1933

to forecast, but any definite improvement in industrial operations should be very quickly reflected in electric production. There is undoubtedly a steady increase in the energy produced for domestic use.

The increase in installation recorded in 1932 was accounted for chiefly by the Beauharnois development in Quebec, the Chats Falls plant on the Ontario-Quebec boundary, and the Corra Linn development on the Kootenay River in British Columbia.

—From Bulletin No. 1631, Dominion Water Power and Hydrometric Bureau of the Department of Interior, Ottawa.

E. J. Barrette, Preston

On December 26, 1932, death came with tragic suddenness to Edward Joseph Barrette, Superintendent, Preston Light and Water Commission. On the Friday evening of the preceding week, Mr. Barrette was assisting in distributing Christmas relief when he was taken ill. His condition became more serious over the week-end, culminating in his death on Monday morning.

Edward Joseph Barrette

Mr. Barrette had been Superintendent of the Hydro Department of the Preston Water and Light Commission for the past eighteen years. Prior to that time he was employed as a foreman with the Canadian Pacific Railway, living at Peterborough, the place of his birth. He was in his fifty-third year.

The following tribute to the memory of the late Mr. Barrette was paid by Chairman F. O. Pelz of the Light and Water Commission—"During his 18 years as Superintendent of the Commission the late Mr. Barrette has shown a true and faithful interest in his work and was ready at all times to carry out work in the interests of the Commission."

Surviving him are his mother, Mrs. Mary Barrette, Peterborough, his widow, and four children, to all of whom the BULLETIN extends sincere sympathy.

Lighting Notes

From the Commission's Illumination Laboratory

THE problems encountered in the lighting service conducted by the illumination section of the laboratories cover a very wide variety of subjects. There is some similarity in the lighting of many types of buildings, although each one is an individual job containing its own features of interest. On the side-lines, however, are many problems, perplexing to those concerned, and often simple in the solution that afford the greatest degree of satisfaction to the individuals to whom the service is rendered.

A few typical examples briefly described may interest the readers of THE BULLETIN:

UNDER-WATER LIGHTING

Not all under-water lighting is for spectacular or display purposes. One application in particular has a very important bearing on the welfare of the inhabitants of a city.

In the filtration plant of a water-works system the water is filtered through beds of sand about 8 ft. deep. In passing through the sand the suspended matter in the water is filtered out and as a consequence the sand requires frequent washing to remove the matter that has been taken from the water. This is done by pumping water through the sand in the reverse direction. This agitates the entire sand bed and the progress of the washing can be watched if light penetrates down into the water so that its turbidity is easily observed. The original installation provided lights just above the surface of the water. As viewed by the operator, little or none of this light penetrated the water to reveal the condition below the surface. The surface of the water acted as a mirror and the light was a hindrance rather than a help.

An under-water unit so revealed the sub-surface condition that the engineer in charge stated that the filter beds could be washed with ¼ of the water that was formerly required.

Thus, what was formerly almost entirely a matter of guess during dull days and nights became a process easily controlled at any time.

A MATTER OF COLOUR QUALITY

During a visit to a Gents' Clothing Store, the proprietor invited the writer to the doorway to examine a light gray fall coat, "examine the cloth carefully under this daylight" said he. Then returning to the interior the same coat was displayed under artificial light. "Now where is the green stripe?" he asked. It had vanished. An inspection of the lighting system was made and blue bulb lamps were installed. It was possible to obtain a satisfactory intensity of illumination of practically daylight color. The proprietor later remarked that he did not then have to take his prospective customers out into the street to show his goods.

There are a great many cases where similar conditions exist. It is true

that the blue bulbs absorb considerable light and larger wattage lamps must be used. On the other hand, one dissatisfied customer may mean the loss of enough revenue to pay for a large proportion of a satisfactory lighting system. The colors and patterns of fabrics, and many other materials, cannot be properly judged under unmodified artificial light when the daylight appearance is required.

The color quality of light has an important effect of an entirely different nature. Advancing years bring many handicaps, one of which is impaired vision. Many elderly persons who do much reading or other close eye work, complain about the light. It is well known that the pupils of the eyes contract as age comes on and higher intensities of illumination are necessary to counteract the decreasing size of the eyes' windows. Larger lamps, however, do not always produce the desired improvement. One elderly lady who had complained was given a blue-bulb lamp for her reading lamp and was delighted with the result. There are many other cases where a white light produced greater comfort for visual work than was obtained from the natural color of tungsten lamp light. It has been proved that in general the eyes work best under light of daylight color, although some individuals may prefer a more yellow light on account of its pleasing warmth of color.

Badminton Lighting

Some time ago a request was received from a Club that was fitting up a building for badminton, for advice on the lighting. A visit was made to several other clubs to observe the lighting in general use. The variety of types of lighting equipment seen was bewildering and sufficient to indicate that the problem had not been solved. They were all of the direct lighting type with various means employed to reduce the inevitable glare.

Lighting for badminton should, above all, be free from glare. Direct lighting is in general use and direct lighting is inherently a glare producer when one must look toward the light sources.

This is the very condition that exists during a game of badminton. Furthermore, the flight of the "bird" is swift during the early part of its course and this calls for rapid judgment on the part of the players, and this in turn demands good lighting.

Recently, an opportunity came to install a temporary system of indirect lighting in a Y.W.C.A. gymnasium, where the badminton players complained about the lighting. The gymnasium was fairly well adopted to indirect lighting and the temporary system did not interfere with old direct system.

The expressions of satisfaction with the indirect system and the vigorous protests when the old direct system was switched on were all the evidence required to prove the merits of indirect lighting.

There are sound reasons for this conclusion, the light is reflected from the ceiling and it is the brightest surface in the room, the "bird" appears in silhouette against it. The ceiling brightness is low enough to cause no annoyance and it is possible to easily follow the "bird" at all times during

its flight, which is not the case with direct lighting.

Many badminton buildings are of the armory type of construction and not very well suited to indirect lighting. However, if consideration of the lighting were given during the planning, it is possible to produce a really satisfactory system at a lower cost than would be necessary when the lighting must be adapted to a building not originally planned for the type of lighting required.

Putting Glare to Work

Glare is the bug-bear of every illuminating engineer. It appears in many forms and under various disguises. It is possible, however, to control one cause of glare so as to convert it from a liability to an asset and make it do useful work.

During an inspection of the lighting of a furniture factory, workmen polishing desk and table tops were seen to bend over, first one way, then another, to see the lamps reflected in the surface being polished, so as to observe the progress of the work.

A lighting unit made up of a small lamp behind a piece of good diffusing glass and mounted on an adjustable bracket made it unnecessary to bend over, the unit can be adjusted to any desired position and the diffusing surface being larger than an ordinary lamp enables the workman to see more of the table top at a glance.

In this case, although the principle of reflected glare is made use of, the unit is not actually glaring as the brightness is reduced to a comfortable value. The same device can be used for many kinds of inspection of flat, or nearly flat, surfaces.

Conclusion

In lighting, as well as in most other activities, attention to apparently insignificant details may result in surprisingly large benefits.

In industrial and commercial work, the value of the time and material lost in a year due to poor lighting may be more than enough to maintain a satisfactory lighting system. The value of good lighting to a firm represents dollars directly, there is also the indirect value resulting from the greater efficiency and physical well-being of the employees.

The few examples cited will indicate some of the ways in which the Illumination Laboratory has been of service to "Hydro" municipalities. Our work has included nearly every phase of lighting and our experience and facilities are available for the benefit of users of "Hydro" power.

—*G.G.C.*

Some Notes on Modern Protective Relaying

By E. M. Wood, Assistant Engineer, Electrical Engineering Dept., H.E.P.C. of Ont.

(*Presented to Toronto Section, A.I.E.E., November 25, 1932*).

I.—DEVELOPMENT AND CHARACTERISTICS OF MODERN PROTECTIVE RELAYING

BROADLY speaking, the aims of relay protection are:—

First — Insurance against fault arc damage to equipment and material to avoid heavy expense for repairs or re-construction.

Second—To enable a high grade of service to be maintained to power users by preventing interruption to that service.

The accomplishment of the second aim depends primarily on careful consideration in the planning of the power system as a whole, that is, on the arrangement of lines and stations, the station diagrams and the like, and then on the application of relay protection properly fitted to and co-ordinated with the system to meet the requirements.

Most systems existing to-day have started on a small scale and grown by additions and interconnections. In the past it has been the more frequent practice to lay out the system and let the relay engineer do his best with the protection. However, the arts of system planning and modern relay protection are very closely allied, and it is becoming more and more the rule before making changes or additions to a system to consider how suitable protective relays can be applied having regard to the existing state of the art, and to make the changes in such a way as will permit this to be done.

On the other hand, it is the duty of those responsible for relay protection to advance the state of the art from time to time in such a way as to take care of service requirements without undue complication or expense, and without unduly limiting the use of what would otherwise be desirable connections or methods.

It is of interest to note how, in the past, the requirements of the power systems have called forth developments in relay equipment and how these developments have permitted further freedom in the expansion of the systems and improvement in the quality of service.

In the smaller early systems, the most apparent characteristic of a faulty circuit, namely excess current, was used to operate a relay, usually a solenoid, to cause the proper breaker to trip to kill the circuit. As desire developed to select the defective circuit and leave the rest of the system operating, timing features often in the form of bellows were added to the relays nearer the generating station.

During the period of about 1908-1912 there was a great development in power generation and stations of 50,000 to 100,000 h.p. began to appear,

with much heavier short circuit currents. Many failures occurred in transformers and oil circuit breakers under the heavier stresses, and the relays either became instantaneous or destroyed themselves in trying to function. Great improvements were called forth in relays as well as in circuit breakers and other equipment. The important contribution of the relay engineers was the induction relay. This way relay was based on the well-tried induction wattmeter, and proved to be simple, rugged and reliable and accurate. The most usual form was the excess current relay with inverse time or inverse-definite time characteristic. The standard method of obtaining selectivity was by graded timing, with the short time on the remote feeders and timing increased by steps toward the generators. This relay is easily made in the form of a wattmeter and as such is naturally directional. This form was applied at receiver ends of line sections and at other suitable locations, as on loops and tie lines to enable the timing to be reduced and to promote selectivity.

It was soon apparent on some of these systems, as they took on important synchronous load, that some means were required to avoid the graded timing to enable faults to be cleared at higher speed. Current balance schemes were developed for multiple lines in parallel between terminal busses to select and trip out the faulty line which was the line carrying heavier current. Differential relaying was developed and applied to the protection of equipment such as generators and transformers. Residual current schemes were developed for clearing lines in case of ground faults on grounded neutral systems.

During the period from 1910 to 1925 a very comprehensive system of protection was built up — chiefly around the induction relay in its various forms although in some cases, solenoid and other types of relays were used where timing was not required, as for example, in differential and balanced schemes. It was applied to the great majority of the important systems on this continent, and on many medium voltage systems where there is no important synchronous load and where the system arrangement permits the use of the devices to avoid long graded times, it meets the requirements in an acceptable manner.

During all this period, the use of electric power was growing rapidly. Larger and larger generating stations, both for steam and water power, were being constructed and being interconnected. There was important development in the transmission of large blocks of power long distance at high voltage. About 1925 we began to hear a great deal about "synchronous stability". If synchronous generators are to operate together on a system they must stay in parallel and they are held in parallel by the ability to transmit "synchronizing" power over the lines from one machine or group to another. The amount of synchronizing power transmittable over a connection is roughly proportional to the square of the voltage. Any fault on the system lowers the voltage on one or more phases and to that extent weakens the tie between the stations and allows the machines to act according to their

local conditions rather than with regard to the requirements of the whole system—they change their relative phase position and speed. When the fault clears, one or more of them is likely to be out of step with the rest and the result is the equivalent of a short circuit on the system. The system has to split up or be killed and started up again.

This phenomenon of instability, which was quite familiar on those systems with heavy synchronous load, began to be noted on the interconnected systems. It became quite serious, because the larger and more widespread the system, the more trouble it is liable to pick up, and the more widespread the effect of the trouble on the system.

After much testing, calculation and discussion, the conclusion was reached that the factor which would contribute most to ensure safe operation of large systems would be the extremely rapid clearance of faults, and that such clearance in a total fault time of 0.15 to 0.2 seconds would be of very great assistance in practically all cases.

For such systems, the conventional type of relaying just described is wholly inadequate.

For two reasons:—

1. The time of clearance is too slow. Graded timing for selectivity is in general not permissible except for remote faults. Even where timing was not intentionally used as in balanced or differential schemes, the best total clearance times (relay and breaker) with high capacity high voltage oil circuit breakers was about one-half second and oftener nearer three-quarters second.

2. The liability of failure to operate was too great. The excess current principle is satisfactory on any line where there is certain to be plenty of excess current in case of a fault. On large systems with high capacity equipment and lines, and with the amount of generating equipment on load at the various points changing from time to time, it is quite certain that at times the fault current over the line may be below the load current value at other times. The excess current principle is not applicable in such cases.

This particular limitation does not apply to medium and low voltage systems where the feeders are of limited capacity, as in the case of urban distribution. On such systems there is nearly always plenty of fault current in excess of maximum load values.

If the practice of operating large systems in parallel was to continue and develop, new designs of oil circuit breakers and relays must be forthcoming.

The oil circuit breaker designers responded by bringing out the new high speed types. Incidentally by adding to the speed, the designers improved the whole functioning of the equipment. Oil circuit breakers were designed which could be guaranteed to rupture a heavy short circuit within their capacity in as fast as 8 cycles on 60, whereas the best earlier breakers required 15 to 30 cycles.

Likewise the relay designers have developed or are developing a high

speed relay system, which will operate in from 0.5 to 2 cycles on 60 cycle system, making a total clearance time of from 0.15 to 0.2 seconds. On a 25 cycle system the total clearance time is somewhat longer as expressed in seconds, but clearances in 5 to 5½ cycles on 25 have been obtained.

When incorporated in a system, planned to take full advantage of them, these accomplishments remove to a large extent the limitations on interconnection of systems, so far as fault conditions are concerned.

Advantages of High Speed Relay Protection.

1. The development of high speed relaying, as we have seen, was rendered compulsory by the requirements of synchronous stability of large systems. Fig. 1 shows in a general way the relation between the amount of power that can flow over a system of lines with a fault on one line for various types of fault and lengths of fault duration. The fault is assumed to be near a generating station so that there is zero voltage in the tie on the faulty phase(s).

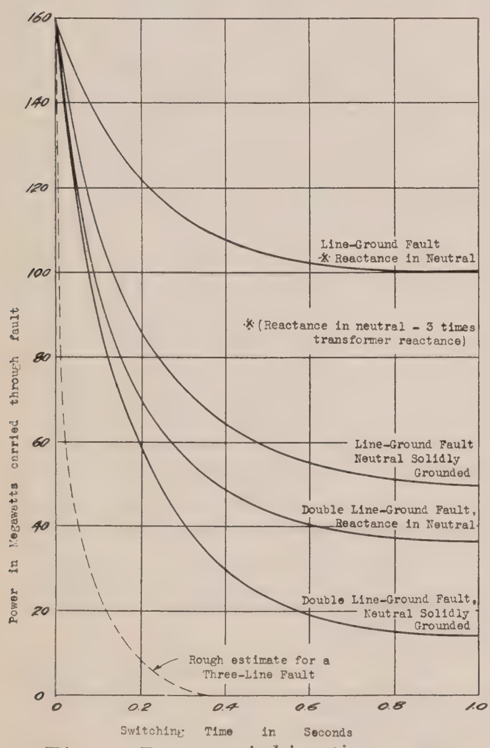


Fig. 1—Power switching time curves.

The figures apply to one particular set of conditions on a particular system and to no other, but the effect of duration of various types of fault on the stability of the system is in a general way as shown. The 1-g fault causes comparatively small disturbance. The 1-1-g and 1-1-1 types of fault are very severe and must be cleared very rapidly.

2. High speed clearance is of great advantage in saving of damage. The amount of damage done by an arc depends on the current in it and on its duration and apparently more on the latter factor. If an arc is extinguished in one-quarter second or less no matter how heavy the current is, it does not seem to have had time to heat up insulation, or conductors to the point of damage or oil to the point of ignition.

Fig. 2 shows an arc of 1,500 r.m.s. amperes at 220 kv. which was started by closing a circuit on a 3 ampere fuse wound around a piece of grocers' twine between phase conductors 15 feet apart. It was cleared in 0.22 seconds, the cotton twine was not scorched and the pitting of conductors where the arc started was scarcely perceptible.

If the arc lasts one-half second there will be severe burning, shattering and spalling of insulators and ignition of oil. Oil fires as in circuit

Fig. 2—1500 r.m.s. ampere arc on a 220 kv. system, initiated by closing against a 3 ampere fuse wire wrapped on twine for support, conductors spaced 15 feet. Fault was cleared in 0.22 sec. and so fast that there was no evidence of burning on the twine.

breakers are, of course, very serious and liable to cause the destruction of a station. In three or four seconds the ordinary system fault current will badly cut or burn down a line conductor if the arc stays in one place. These remarks apply to arcs in wiring, rather than in apparatus.

3. Rapid clearance tends to prevent an l-g fault, which is the more usual initial type, from involving additional phases thus producing the much more serious type of fault. The time required for spreading depends on the conductor spacing and on the speed of the wind. The arc bursts out immediately to a diameter of 2 or 3 feet, then travels sidewise with the wind and upwards at about 30 or 40 feet per second.

Delay in clearance also tends to allow the arc to spread at the same rate to other circuits on the same tower or right-of-way, causing a still more serious danger to service.

4. Rapid clearance of faults alleviates the shock to equipment caused by single phase faults which is quite severe if prolonged. It is of great assistance to the operators on a system if they can depend on a fault being cleared quickly. An operator on a large system will usually know that there is a fault on the system, but he has very little means of knowing its location unless he happens to see it. This particular advantage does not call for extremely high speed but it does require certainty of clearance in a second or less.

Characteristics of the High Speed System

The maximum advantage of high speed relaying is obtained if as applied to the system it has the following characteristics:—

1. It should be sensitive and positive in its operation, to the end that it should quickly eliminate any fault which causes damage or voltage disturbance. This involves—

(a) That the protection should be complete, so far as the main part of the system is concerned. There should be no equipment or busses or lines which are not covered by the high speed protection, unless there is certainty that a fault cannot occur in them.

(b) That it should operate with suitable speed under all reasonable conditions of system arrangement and connected generator capacity at various stations. It should permit, without loss of effectiveness and without adjustment, the best use of the station and line equipment to meet the operating requirements or contingencies. If it cannot be made to do this, at least the limitations should be understood by the operating staff.

2. It should be selective—that is, it should remove from service the element of the system containing the fault, leaving the remainder of the system in operation.

3. Speed: The speed requirements for synchronous stability on large systems have been indicated. This requires use of both high speed in circuit breakers and in relays. However, on many systems where high speed breakers are not required and not considered necessary, the methods used in applying complete high speed relaying may be usefully applied without extremely high speed in the relays.

4. In order to obtain certainty and speed of clearance with selectivity, it is necessary to free the relaying from the effect of load currents and of system arrangements.

The modern idea in protection is not the application of the protection to each automatic breaker. The basic method of modern protection is to consider the system as made up of separable elements to each of which relaying is to be applied in such a way that it pays no attention to faults external to the element, but does operate whenever a fault exists in the element to eliminate it from the system instantly. Such a system does not require timing for selectivity.

The elements of the system are generators, transformers, busses, and lines or feeders on groups of these.

It may be of interest that this method which is being generally applied to lines on most important systems and is becoming accepted as best practice on all important new work for both stations and lines was pioneered and developed to a large extent in Canada and has been used for about ten years on large Canadian stations and lines.

II. Methods of High Speed Relaying — Application to Stations. Zone Differential Protection —General.

Station Zone Differential Protection—

In a station, the boundaries of each element are close together and the general method used is that of zone protection, usually of the differential type.

In order that this type of protection should be applicable to a station, the diagram must be such that it can be divided into elements or "zones" each of the "portals" of which is covered

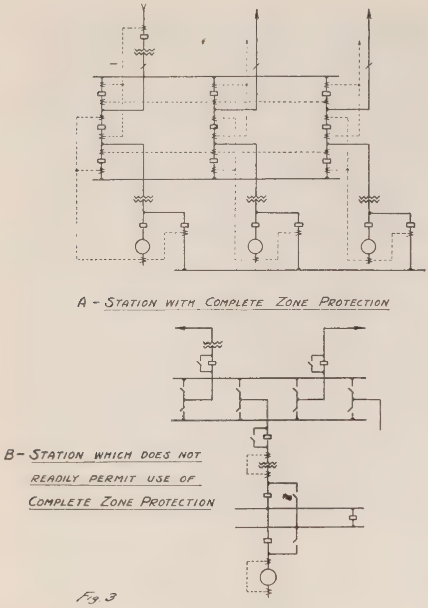


Fig. 3

by an automatic oil circuit breaker so that the "zone" can be isolated from the station by opening these circuit breakers. The zone may consist of wiring only, as in case of a bus, or it may contain rotating machinery or transformers. Fig. 3 shows at A the diagram of a station with complete zone protection. It is to be noted that every part of the station is included in one or the other of the zones. At B is a diagram which does not readily permit of complete zone protection. In this case, the protection would be applied to generators, transformer banks and lines. The busses and main wiring could be covered by instantaneous protection but at the expense of considerable complication.

The additional requirements for zone protection are:—

1. Current transformers are required on each phase at each boundary breaker on the side remote from the zone protected. These must be all similar in ratio and characteristics. It is usually convenient that these be of the bushing type, but it is not necessary.

The current transformer secondaries are all paralleled so they sum up the total current flowing *into* the zone and the sum of these currents is taken through a relay for each phase or residual as desired. If the zone is normal, the total current to the zone is zero—that is the ingoing current in each phase is equal to the outgoing current, and there is no current in the relays. (See Fig. 4.) If a fault occurs, some of the current in one or more phases leaves otherwise than through the current transformers, the sum is not zero, and a corresponding current appears in the relays causing tripping. This protection is independent of all external conditions. Subject to certain adverse conditions to be discussed later, it may be set as sensitively and as fast as desired. It brackets each of the zone breakers.

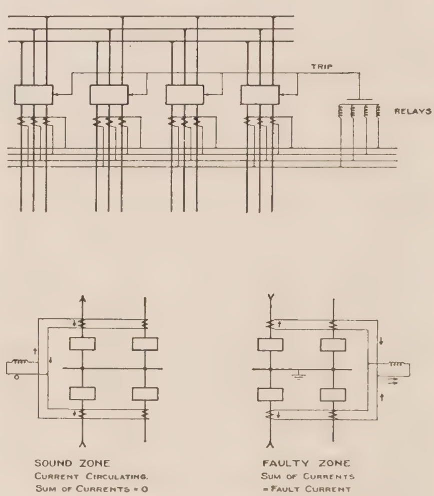


FIG. 4
PRINCIPLES OF ZONE PROTECTION

It will be seen that it is not allowable to have "portals" to the zone not covered by current transformers and oil circuit breakers.

2. Consideration must be given to the combination of the characteristics of current transformers, secondary wiring and the burden imposed by the relays, so that the desired sensitivity can be obtained. To determine the proper sensitivity it is necessary to know *the minimum current which will flow in a fault in the Zone.*

If several sets of current transformers have to be connected in parallel, as is often the case, the actual ratio of the current transformer may become much greater than the apparent ratio due to the large component of primary current required to magnetize the multiple current transformer cores, and which, therefore, does not appear in the secondary circuits. In general, burdens in the relay circuits must be kept to a low value if the ratio error is to be not excessive.

3. The characteristics of current transformers should be such that they do not approach magnetic saturation of the cores in the case of the *heaviest fault currents which will pass through the zone* which must be known. Current transformers when worked at secondary voltages approaching saturation are liable to be erratic in ratio which may give rise to sufficient unbalance secondary currents to trip the relays if set sensitively. This condition required that the impedances of the secondary windings and of the circulating circuits should be kept as low as necessary and that current transformers of suitable ratio should be used.

4. If currents with heavy d.c. components pass through the zone, the current transformers may not all respond alike to the d.c. component with the result that a current of the

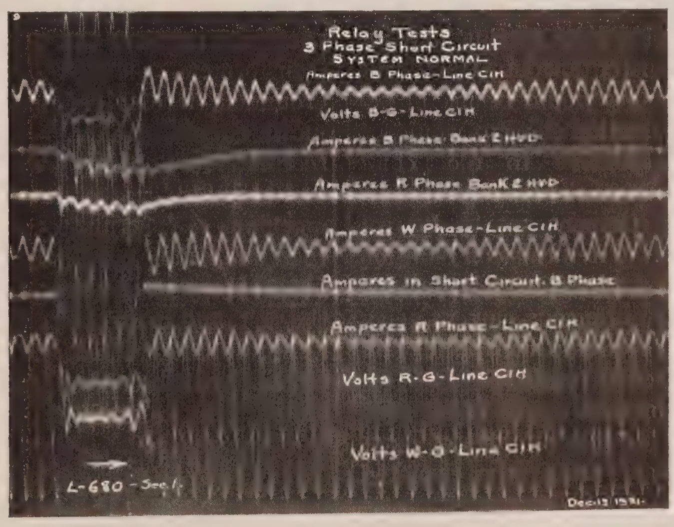


Fig. 5—Short circuit oscilligram showing effect of d.c. component of primary current on differential relay current curves marked 2 H.V.D. Note value of differential current after clearance of fault.

type shown in Fig. 5 may appear in the relay circuit of sufficient value to trip a sensitive relay. This d.c. differential rises to a maximum at the time the d.c. component disappears and then dies away to zero.[1]

These characteristics limit the sensitivity of the setting which can be applied to a zone differential relay. Their effect can be controlled by attention to the details of design such as ratio and characteristics of current transformers, impedances of circuits and balancing of current transformers and circuits, with the result that safe and adequate zone differential protection is quite feasible in practically all cases.

The relays should be sufficiently sensitive to operate on any zone fault when the minimum useful number of generators is connected to the system. They should be high speed for heavy faults, but a slight time delay would usually be allowable for light faults. A sensitive induction relay with lowest possible time setting and including an instantaneous attachment for heavy faults would be useful because the induction element would be largely irresponsive to d.c. components and transients, and the instantaneous element would be set above them. Often this combination will have too high impedance in which case the instantaneous current relay set as low as is safe will be usually found sufficiently sensitive.

These principles apply to all zone protection. In new stations of moderate voltage, using the isolated phase type of construction, suitable protection for a section of bus with its tie, feeder and generator circuit breakers may be obtained by lightly but thoroughly insulating the complete structure from the building. All the metal work of this section is tied together and connected to the station ground through a current transformer which supplies an instantaneous relay arranged to open the necessary breakers to isolate the section. With this type of construction any fault will be 1-g and the current will pass to ground through the relay which may be set as fast and sensitively as desired.

III. Zones Containing Rotating Machinery

The principles and requirements of zone protection apply fully with some additional requirements due to the characteristics of rotating machinery.

The neutral of a star-connected generator becomes a "portal" to the zone and requires the usual current transformers. If the neutral is grounded, it also requires an automatic circuit breaker. Provision is required for quickly removing the excitation in case of a synchronous machine. The protection should, therefore, not only trip the zone boundary oil circuit breakers but also the field and neutral circuit breakers. As would be expected, the opening of a field circuit breaker does not immediately remove the flux and voltage from the generator. On a large unit, it may take 5 to 10 seconds for these to die down to zero. Various schemes have been proposed to hasten this process, including a proposal to momentarily reverse the excitation.

[1] For a discussion of this effect see "Current Transformer Excitation under Transient Conditions—Marshall and Langguth—A.I.E.E. Transactions, October 1929, Page 1464."

This would involve much complication, and in one case at least, for which the writer has seen calculations, the gain in speed was comparatively small.

As a matter of fact, the rapid opening of the generator field circuit breaker seems to be sufficient to prevent serious burning from this cause in practically all cases.

For the circuits of the zone external to the machine, the requirements are those covered in general for zone differential protection.

For faults in the armature winding of the rotating machine the protection is primarily for the purpose of minimizing damage and expense for repairs and of safeguarding service by enabling the equipment to be returned to use without long delay.

Armature faults may consist of:—

Failure between turns of a single coil.

Failure between coils of the same phase.

Failure between coils of different phases.

Failure to ground.

Besides the arc damage to the coil or coils, an arc playing on the core laminations will very quickly cut them away, or weld them together, in which case it may be necessary to tear down and restack the laminations to avoid high local heating—a very expensive job.

The arc may be blown around the machine by windage, damaging numerous coils or even causing destruction of the winding by fire. It is, therefore, highly desirable that the clearance and de-energizing of a faulty armature be sensitive and fast.

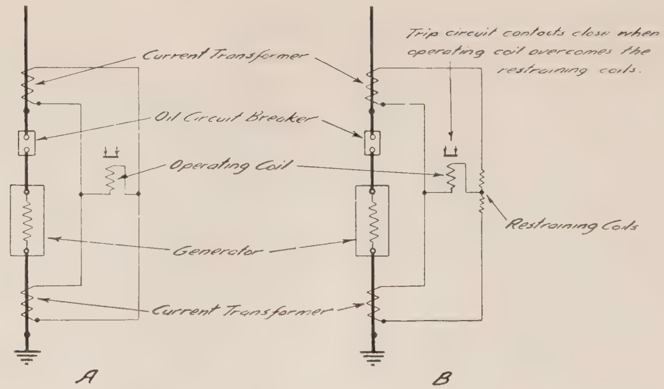
The detailed requirements depend on the treatment of the winding neutral.

1. If the neutral is grounded directly or through low impedance, the zone differential can usually be made sufficiently sensitive and fast to give adequate protection. If grounded through an impedance a section of the winding next the neutral will not be protected because a ground in it will not cause sufficient current to trip the relay. The higher the impedance, the more sensitive the relay required to cover a given percentage of the winding. On the other hand there is less voltage near the neutral to cause a fault.

This protection does not cover faults between points in the same phase unless they involve ground, which they may not do for some time if the fault is between turns of a coil or at the coil ends. Such faults will hang on until the arc grounds somewhere.

Current or percentage differential type relays of the induction type have been used for generator zone differential but are not as fast as is desirable for machine faults.

The application requires high-speed type as modern circuit breakers at machine voltage are inherently fast. Instantaneous current relays have been used successfully on a number of installations. (See Fig. 6a). High speed relays based on the percentage differential principle have also been developed. This type, (see Fig. 6b) contains two coils. One, carrying the load current acts to prevent tripping, the other carrying the "differential" current causes the relay to trip by overpowering the load current coil when the fault or differential current



One-line Diagram showing Elementary Connections of Current-differential Protection of Generator, using
A. Differential Current Relay
B. Percentage Differential Current Relay

Fig. 6

reaches a certain percentage of the load. This arrangement prevents tripping on heavy external faults by automatically increasing the setting, thus allowing a more sensitive setting than can be given a plain current relay to be safely used for internal faults. The development is new in the high speed construction and will be watched with interest. The writer is not entirely sure of its stability on the d.c. transient differential shown in Fig. 5 as there would appear to be a possibility of sufficient differential current to trip the relay after the restraint is removed.

2. If the neutral is free or grounded through a high impedance, the zone protection will operate only on phase-phase faults, and while required for these will not operate for faults involving only one phase, even if such fault should be a double ground. It must be supplemented by—

(a) *A ground detector.*

In general it is not permissable to operate a generator with a high or infinite impedance in the neutral without a ground detector, because an arcing ground may in time cause a second breakdown.

Ground detection can be obtained by—

A current relay in the neutral circuit if a neutral impedance is used.

A potential transformer between neutral and ground, with a potential relay.

A set of three potential transformers connected between the three-phase leads and ground with secondary connected in broken delta which supplies the residual voltage of the system to the relays. This will indicate a ground.

In applying these schemes which

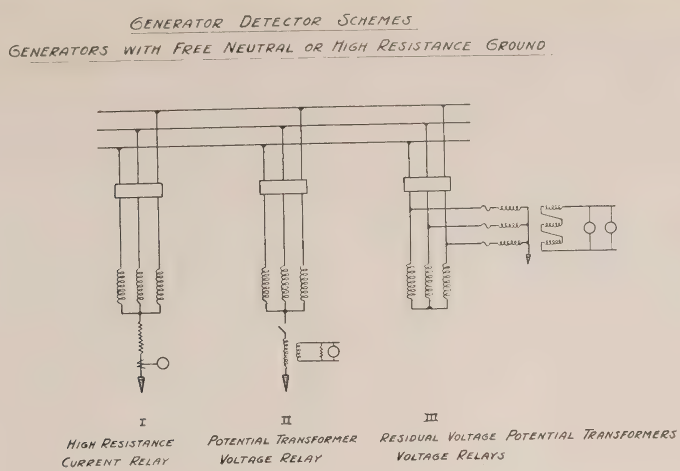


Fig 7

are shown in Fig. 7 the following should be borne in mind.

The detectors will show a ground at any point in the metallically interconnected system. They do not indicate which zone is grounded.

The detectors of either of the two last schemes may, due to the combination between their reactance and the capacity of the machine windings and bus cause voltage instability and possibly dangerous voltages. There are means, such as loading the secondaries, of overcoming such tendencies.

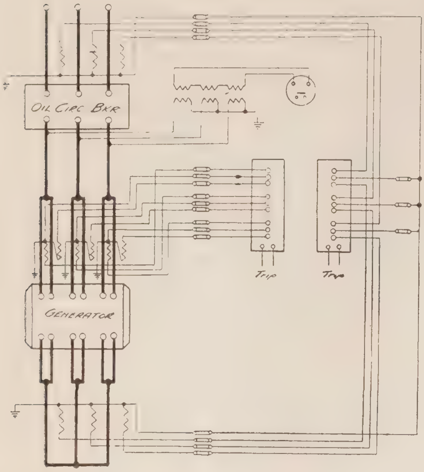
They are affected by residual voltages, such as triple frequencies generated by the machine; also voltage unbalance from the high voltage side of a transformer bank may be reflected through the electrostatic capacity of the bank or by electromagnetic coupling.[2] In general, such a ground detector should be used to give an alarm rather than trip out the zone, and for such purpose the relay should be set above the continuous factors in which case they will still be sensitive enough to detect a ground within one or two coils of the neutral. In case generators are paralleled as through a synchronizing bus, it is sometimes possible to use this detector to separate the units from the bus so that the grounded unit can be quickly found. This will also tend to prevent a fault in one unit from inducing a second breakdown in another unit. For this purpose a second relay of setting above ordinary transient disturbances and with a short timing would be used.

(b) *Protection against faults internal to one phase.*

Where the armature winding consists of two or more similar parallel circuits as is usual in most large units, the most suitable form for this is the "split-phase" protection.

If there is no fault in a phase winding, the currents in the two halves

[2] Effect of Transient Voltages on Power Transformer Design—IV Palueff and Hagenguth A.I.E.E. 1932.



Generator Split Phase Differential Protection
Generator Zone Differential Protection.
Generator Armature Ground Detector

Fig 8

are approximately balanced. For the split-phase protection, the currents in the two half windings of each phase are compared in the protective circuit and the unbalance taken through a relay. (See Fig. 8.)

These should be high speed, and may be of the instantaneous current or of the percentage differential type, similar to those for generator zone differential. In addition to the usual limitations to sensitivity, this relay must take into account the normal unbalance between the half winding which may be caused by:—

1. Unsymmetrical grouping of coils.
2. Mechanical inaccuracies as in air gaps.

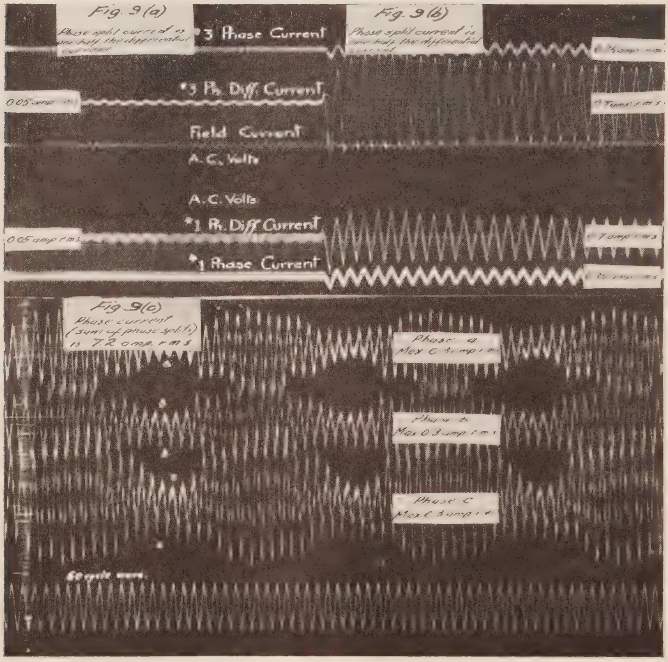


Fig. 9 (a)—Normal unbalance of phase splits of one generator at no load.
Fig. 9 (b)—Same generator with one armature coil short circuited, at no load.
Fig. 9 (c)—Normal unbalance of phase splits of a second generator at full load.

3. Short-circuited turns or coils in the field winding.

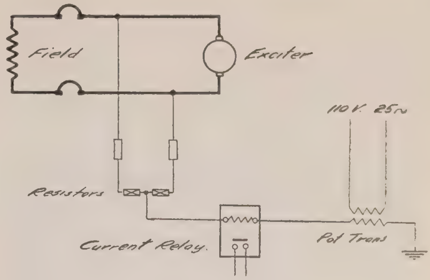
The first and second causes can usually be overcome to a large extent if the winding is designed for application of split phase protection.

The third cause of unbalance may occur accidentally. A short circuit of any considerable portion of a field winding will cause dangerous vibration. One advantage of the split phase protection is that it will quickly clear a machine with sufficient short-circuit to cause serious vibration.

However, a few turns short circuited in the field winding will cause noticeable unbalance in the split phase.

Fig. 9a shows the unbalance current in one generator where the normal unbalance is very small. This also shows at B the increase in unbalance due to one short-circuited armature coil (3 turns per coil, 54 coils per circuit, 12 poles in series in the winding). The split-phase protection on this unit could be set to be very sensitive and on test cleared the unit with certainty for a short-circuited coil and probably would do so for a short-circuited turn.

In some machines (an example of which is shown at 9c) the normal unbalance is fairly high due to unfavourable requirements in the winding. If these happen to have a large number of poles, it is highly doubtful if the protection could be made to operate on a short-circuited turn or coil, but would operate on a group to group fault in the phase.



Field Ground Detector.

Fig. 10

3. In a synchronous machine it is highly desirable to detect a ground on the excitation circuit. If the first ground is detected and repaired there is much less danger of a dangerous short-circuit developing in the field winding due to a double-ground.

There are a number of suitable ways of accomplishing this one of which is shown in Fig. 10.

4. For water wheel driven generators with direct connected exciters where there is danger of high exciter voltage in case of overspeeding on rejection of load, some scheme to limit the exciter voltage is desirable. This can be usually obtained as part of the voltage regulator equipment, but it should be in service at all times whether the voltage regulator is being used or not. It usually takes the form of a simple supplementary voltage regulator.

Continued in February's issue.

Electricity in an Abattoir

Stunning a pig by electrical means prior to "sticking"

An electrical method of stunning pigs prior to "sticking" has now been standardised in the Sheffield abattoir after experiments ranging over a few years. The apparatus, invented by Professor Muller, of Munich, in 1926, was tried by Messrs. Marsh & Baxter, Brierley Hill, Birmingham, but proved unsuccessful. Improvements were made and in 1931, the method was successfully used in Germany. At a demonstration in Sheffield, attended by members of the Health Committee, the killer proved to be so far in advance of other methods that it is now used regularly.

The instrument is connected to the mains, and the energy is transformed to 60-80 volts. The current is passed through insulated tongs. The electrodes at the end of these are placed just behind the pig's ears and the current switched on by means of a press button. The pig is rendered unconscious immediately, but no danger attaches to the operator should he accidentally touch a "live" part. Mr. W. Tweed, the chief veterinary surgeon of the Sheffield abattoir, states that experiments have proved that the objectionable condition known as "blood splashing" which is usual when the pistol bolt is used is entirely eliminated, and better bled meat is produced.

—*The Electrical Review.*

Central Station Lighting

By C. B. Stephens, Electrical Engineering Dept., H.E.P.C. of Ont.

CENTRAL station lighting differs from that of most other buildings in many essential details. Since it does not directly contribute to sales, as does that of stores or theatres, it is not spectacular in either form, colour, or quantity. Also, since it does not directly increase production except in machine or repair shops, it is not designed to accommodate frequent changes in layout or intensity of illumination as is required of good factory lighting. Central station lighting, therefore, is designed for its special service to adequately illuminate each component part of the station for its particular function and maintenance. Reliability of service, ease and safety in re-lamping or cleaning and simplicity of layout are important factors in producing a satisfactory installation.

From the preceding statement of the requirements for central station lighting, it is apparent that the designer of a lighting system should ascertain beforehand all possible information regarding the kind of work to be undertaken in each portion of the station. It is of equal importance to know the location, mode of assembly and use of each major piece of equipment.

Below are brief descriptions of the lighting equipment together with the lighting requirements for various sections of a central station property.

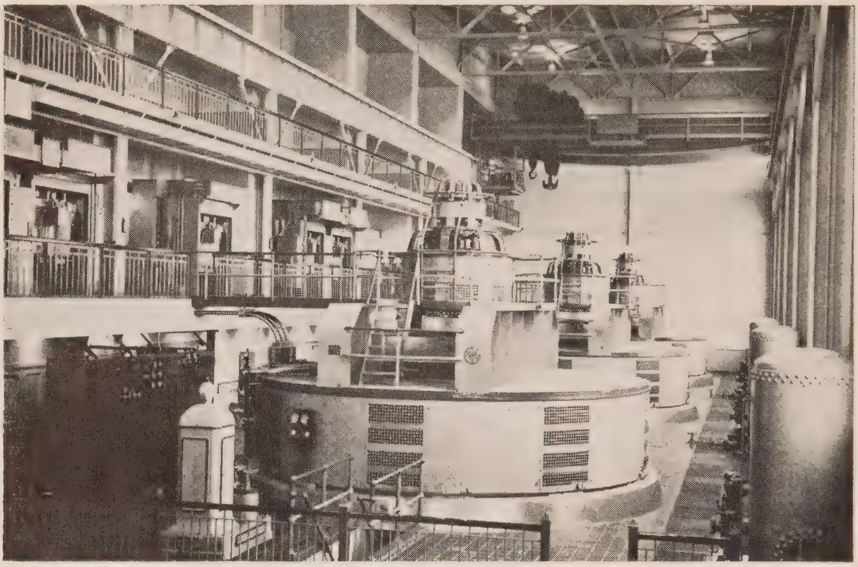
Generator Rooms

The generator room in stations housing several generators is large in all dimensions—40 to 60 feet wide, 40 to 55 feet high depending on space required for the travelling cranes to place or remove generator parts, and of a length depending on number of generators at a spacing of from 40 to 75 feet, depending on physical size. These rooms are best lighted when using two to three high bay lighting units per bay of steelwork, with lamp sizes ranging from 750 watts to 1500 watts. These high bay units are available in prismatic glass, mirrored glass, or polished chromium types. Assuming two units per bay of 25 feet a generator room 600 feet long would therefore require 48 kw. in 1000-watt lamps.

The high bay units are readily maintained by mounting them above the lower chords of the roof trusses making them accessible from the travelling crane. For generator rooms having plastered ceilings, lighting domes are built in to harmonize with the architecture. Lamps and domes are accessible from walkways spanning lower roof truss chords.

The great mounting height above the floor practically prevents direct glare from lamp filaments and the shadows cast by equipment are soft by virtue of light from several lamps overlapping at any spot except along side walls.

To aid the crane operator in spotting large generator parts during erection of machinery, or in overhauling work, the use of four or more 500-watt spotlights supported from the crane end frames has proven very



Night view of generating room in large hydro-electric plant showing galleries and location of generating room lighting units.

useful. These spotlights are readily supplied with current from a dry type transformer fed from the crane control panel.

Switch Galleries

Switch galleries generally run the full length of the generator room, range in width from 12 to 20 feet or or more, with ceiling heights from 10 to 15 feet. These rooms may be lighted similarly to the generator room, but by utilizing at least four outlets per bay with lamp sizes from 150 watts to 300 watts. Here it is often necessary to have some spill light on the ceiling and to achieve this prismatic glass reflectors prove useful. Objectionable glare from open-type reflectors may be much reduced by using the inside frosted lamp recently made available in these sizes.

Pump rooms, service rooms, etc., are satisfactorily lighted in a similar manner to the switch galleries.

Control Rooms

Control rooms vary considerably in contour, architecture and interior finish with the result that lighting must be "tailor made" for each case. Control boards a few years ago were in the form of full size switchboards with bench sections in front housing controllers and indicating lamps, while the vertical portions accommodated indicating meters. Recently these boards have been greatly reduced in size by making use of miniature size indicating instruments and controllers and lenses of the dimensions of telephone keys and lights. Due to these miniature boards smaller control rooms are possible.

Good lighting may be obtained by either indirect units, cove or lens assemblies. The latter two types

probably entail more maintenance to replace or clean the greater number of lamps than is required with the indirect lighting from relatively few suspended units. The miniature control boards tend to limit a good level of lighting as such high intensity may "wash out" the comparatively feeble light from the signal lamps.

However, nothing very explicit can be said about control room lighting on account of the variety in designs encountered as outlined above.

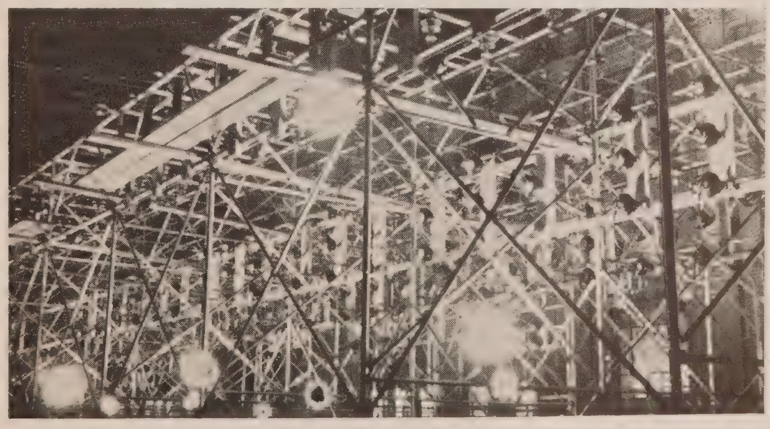
Special Lighting

One interesting application of special lighting is that required for relay panels, of which there may be several in a group. On each panel are mounted a number of relays of different sorts, many of them embodying adjustable features and operation targets. When relays operate it is the duty of the operator on shift to ascertain quickly which group of relays functioned and, if possible, the nature of the disturbance. It is of great assistance, therefore, to have the panels well lighted in order to promptly identify which relays operated.

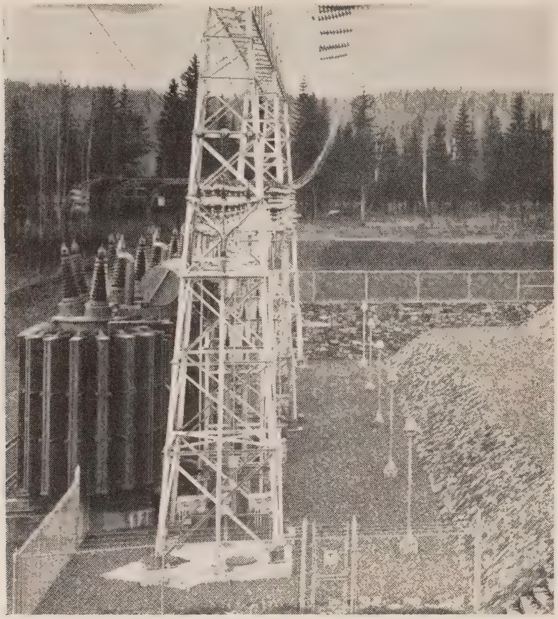
Relays thus mounted may be adequately lighted by means of small prismatic lenses assembled close together in a metal housing or trough, a lamp and reflector being located at correct focus behind each lens. If high intensity lighting is required it can be obtained by using 100 watt lamps at 6½ inch centres, or a lower level of illumination can be used using 60 or 40 watt lamps. A less expensive arrangement is sometimes resorted to consisting of suitable small mirrored glass show window reflectors assembled on metal wiring duct. The prismatic lens assemblies are suitable for well appointed control rooms, while the latter type are "at home" in terminal or relay rooms.

Switch Yard Lighting

Outdoor substation lighting units essentially comprise a street lighting refractor and an outer protective cover glass, all assembled on a base housing containing the lamp socket. The assembly is arranged for bracket or pedestal mounting. Such lighting



Night view showing outdoor lighting of a 13.2 kv. switching structure. Note illumination of disconnecting switches.



Lighting arrangement for a simple structure.

units, when spaced from 15 to 25 feet apart and at a height not less than about 8 feet above the ground, provide very good light for night operation of outdoor switching stations. Considerable care is necessary to obtain the best results with the least expense, as the location of each unit must be chosen to project the smallest shadows on disconnecting switches, bushings, etc. due to intervening steelwork and at the same time project the maximum light on the switches. Clear lamps in the 300-watt size are generally used.

Floodlight projectors may be used with satisfaction when the switch structure is one bay wide and the disconnecting switches are all located on one side On structures of greater width, however, the light may be badly intercepted by intervening structure frames and if floodlights are located on both sides disagreeable glare will often prevent good vision.

Wiring

Electric light wiring in central stations shows marked economy in cost when utilizing 3 phase, 4 wire service from the lighting transformers through to the branch circuits. For example, a 2 wire, 120 volt circuit of No. 12 wire will carry 5 amperes a distance of 60 feet with a 2 volt drop, whereas a balanced 3 phase, 4 wire circuit in No. 12 wire will carry just twice the current on account of the voltage drop occurring only in the phase wire, the neutral carrying no current. Hence two wires will handle 5×120, or 600 watts, whereas 4 wires will handle $3 \times 10 \times 120$, or 3600 watts. In other words, twice the quantity of wire will supply 6 times the load.

Wire with wax finish in red, green, blue and white colours, make it unnecessary to ring out circuits to get the specified outlets on each phase wire and to arrange load balance.

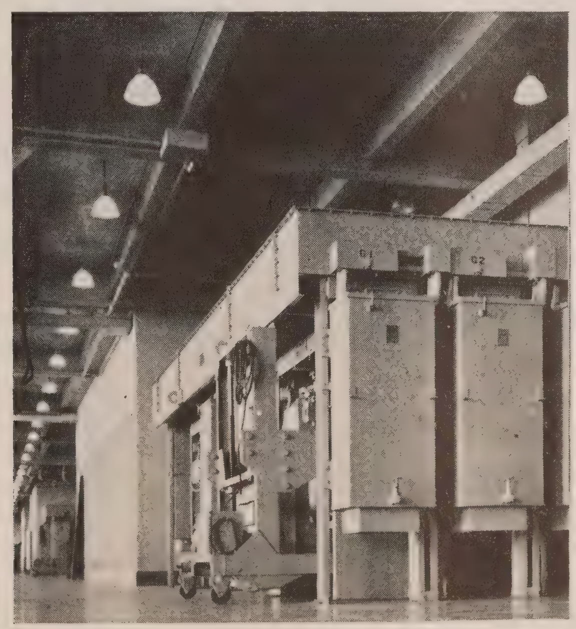
Since the 3 phase distribution permits larger currents per wire, the number of branch circuits for a given load is decreased. Small approved circuit-breakers, instead of switch and fuse control, for branch circuits keep the heating in the panels to a minimum, especially on the heavier loads made possible by the 3 phase, 4 wire system.

Emergency lighting for switchboards, control room, stairs or other vital operating areas, is supplied through an automatic transfer switch from the station control battery. The outlets serving emergency lights are normally supplied from the a.c. service so that no additional lighting outlets are required. By keeping the circuits alive from either the normal a.c. or emergency source of power, assurance is given that the circuits and equipment are healthy and in good condition at all times and therefore require only routine maintenance.

In conclusion, it is felt that the central station should lead the way in advancing the art and science of better lighting as the distribution and sale of lighting energy is its job.

Note: All illustrations shown in this article are of recently built Canadian stations.

The first illustration, page 22, is a night view of the generator room floor of a large hydro-electric plant. The effectiveness of the high bay lighting units will be noted, as there are no harsh shadows and the detail of the equipment is easily defined.



Details of gallery lighting in a large powerhouse.

The illustration on page 23 is an example of outdoor switching station lighting. For this type of structure, the location of each lighting unit must be chosen with great care in order to obtain the best possible results. Not only must the units be placed to give good illumination, but there should be the minimum of projected shadows and the minimum of glare. Outdoor steel structures of this nature often require considerable ingenuity on the part of the illuminating engineer.

The illustration on page 24 shows another type of outdoor structure more simple in general arrangement and therefore not so difficult to illuminate adequately. Note the tall standards used.

The illustration on page 25 shows the arrangement of lighting units for a gallery. Note symmetrical arrangement of units.

About 2,000 years ago the Rajah Bhoj built this dam and flooded some 200 square miles of country. About 400 years ago one of the Mogul Emperors felt the need of more farm land and he kicked a hole in it. Now the Nawab wants me to plug the hole. It's only about 250 feet wide and the dam is over a mile long. Puzzle—Find the monkey.—H.G.A.

Air Conditioning

From the Electric Utilities Standpoint

By D. W. McLenegan, Assistant Engineer, Commercial Engineering Division, Air Conditioning Dept., General Electric Company, Schenectady, N.Y.

(Presented to Association of Municipal Electrical Utilities at Toronto, January 24, 1933).

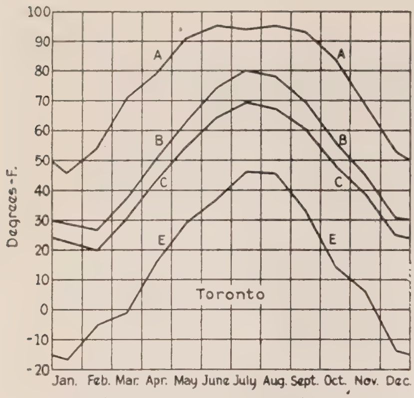
AIR conditioning, in the broadest sense, means changing the climate within a building to provide the most comfortable conditions for the occupants or to meet the requirements of some manufacturing process. The climate has certain deficiencies or excesses which need to be corrected; air conditioning provides certain remedies which we can apply. Various climates, like doctor's cases, require different kinds and degrees of correction. Therefore, it is well to analyze briefly what our technique includes and what climatic conditions we will encounter, before we prescribe the air conditioning cure or attempt to estimate the power load which it will involve. Although many industries now use air conditioning apparatus, this discussion will be confined to equipment suitable for homes and small commercial buildings.

Air conditioning includes specifically:

1. Control of air temperature.
2. Control of relative humidity, or moisture content of the air.
3. Fresh air supply and cleaning, to remove odours and dust.
4. Circulation of the air.

In Ontario, temperature control becomes a rather one-sided affair, since the heating season is long and the temperatures are relatively low. The gradual development of automatically controlled heating plants has made possible the more accurate control of the temperature in heated buildings, as well as the more efficient use of fuel. Since the season for summer cooling is relatively short, and the temperatures are seldom extreme, it is difficult to predict the demand which will arise for this phase of air conditioning.

The regulation of humidity is very important in promoting human comfort. It is well-known that with low outdoor temperatures, the indoor air tends to become very dry unless water vapor is constantly added. Although the relation between humidity and health has not been established beyond question, the evidence in many cases points to an improvement in health where proper equipment is installed to maintain a relative humidity of 40 per cent. to 50 per cent. in winter. On the other hand, the very humid conditions which frequently prevail in summer, even when the temperature is not extremely high, call for equipment to dehumidify the air. Cooling equipment usually is used for this purpose in addition to its other function of reducing the tem-

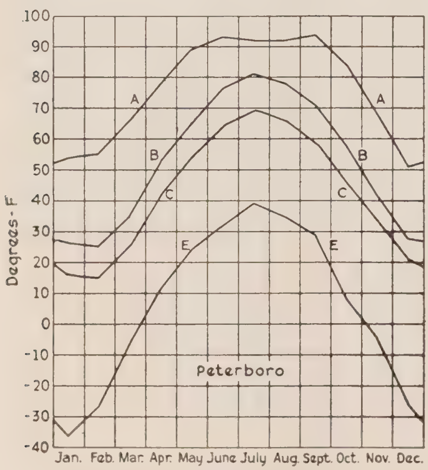


AA: Maximum recorded during month 1924-30
BB: Mean (CC) plus one-half average daily variation
CC: Mean of 90 years observations
EE: Minimum recorded during month. 1924-30

Fig. 1. Climatic Temperatures of Toronto, Ont.

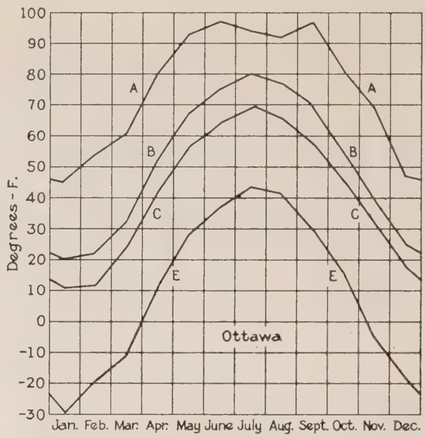
perature. The cold surfaces remove some of the moisture from the air, just as a pitcher of cold water in a warm room becomes covered with water condensed out of the surrounding air.

The advantages of clean air can hardly be questioned. A properly designed ventilating and cleaning system must not only have capacity adequate to handle several air changes



AA: Maximum recorded during month 1924-30
BB: Mean (CC) plus one-half average daily variation
CC: Mean of 60 years observations
EE: Minimum recorded during month 1924-30

Fig. 2. Climatic Temperature at Peterboro, Ont.



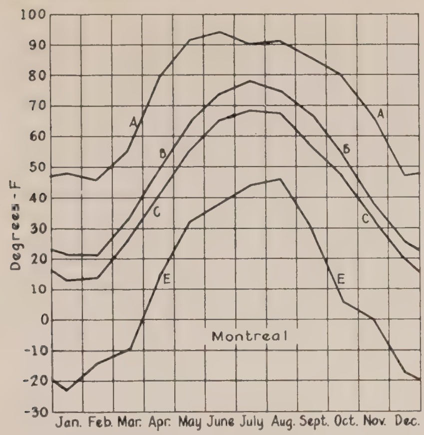
AA: Maximum recorded during month 1924-30
BB: Mean (CC) plus one-half average daily variation
CC: Mean of 40 years observations
EE: Minimum recorded during month 1924-30

Fig. 3 Climatic Temperatures at Ottawa, Ont.

per hour in the occupied room, but must also distribute this air without causing drafts. As a by-product, it can eliminate much of the noise which we now tolerate in offices which are ventilated by opening the windows. By properly directing and controlling the circulation of air, we may remove the stale air and tobacco smoke. We can also improve comfort by reducing the temperature difference between the breathing level and the floor level, whereas this difference may amount to as much as 10 degrees in cold weather if the air is not kept in adequate circulation.

The Climate

To determine the operating requirements for air conditioning equipment, temperature charts (Figs. 1, 2 and 3) have been prepared for the Cities of Toronto, Peterboro and Ottawa, respectively. These records are based on the Meteorological Observations, published monthly by the Department of Marine and Fisheries, of the Canadian Government. A



AA: Maximum recorded during month 1924-30
BB: Mean (CC) plus one-half average daily variation
CC: Mean of 55 years observations
EE: Minimum recorded during month 1924-30

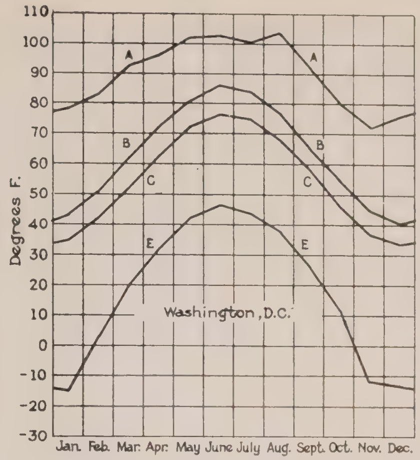
Fig. 4 Climatic Temperatures at Montreal, Que.

similar chart (Fig. 4) is included for Montreal and for comparison, the temperature records of Washington, D.C. and Los Angeles are shown in Figs. 5 and 6.

In all of these charts, curve AA shows the highest temperature attained during any month over a period of several years. The temperatures recorded during the summer months, therefore, indicate the maximum conditions for which a cooling equipment must be designed to operate. Curve CC indicates the mean temperature for each month. Curve EE indicates the lowest temperatures recorded during each month, and the readings for the winter months give an index of the maximum capacity for which heating equipment must be designed. Since all of these curves are based on the combined records of several years, they may not accurately represent the requirements of any specific year.

Determination of Heating and Cooling Seasons

The next step is to determine the number of hours operation which may

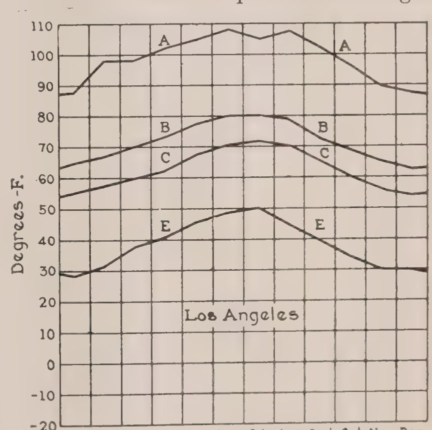


AA: Maximum ever recorded during month
BB: Mean (CC) plus one-half average daily variation
CC: 31 year mean temperature
EE: Minimum ever recorded during month

Fig. 5 Climatic Temperatures at Washington, D.C. From Monthly Records Covering 31 Years

be expected for the various types of air conditioning equipment, based on the length of season during which each type is used.

The heating season is taken as the period during which the monthly mean temperature is below 65 degrees. Figs. 1—4 indicate that these Canadian cities require some degree



AA: Maximum ever recorded during month
BB: Mean (CC) plus one-half average daily variation
CC: 31 year mean temperature
EE: Minimum ever recorded during month

Fig. 6. Climatic Temperatures at Los Angeles, Calif. From Monthly Records Covering 31 Years

of heating for approximately ten months of the year.

The maximum required heating capacity is usually based on a temperature 15 degrees above the lowest ever recorded. The total heating effect for the season is the summation of the amounts by which the daily mean temperature fell below 65 degrees, and is obtained from the degree-day handbook of the American Gas Association. Since an automatic heating plant operating continuously would give a degree-day product equal to the number of days by the maximum heating range, the number of hours operation of such equipment is found by direct proportion, (i.e., the actual degree-days, divided by the maximum possible degree-days of plant output). This number of hours is based on a 24-hour per day heating requirement, and is arbitrarily reduced by 20 per cent. to take account of the over-capacity usually found in automatic heating plants.

The operating season for humidifiers has been taken as the time during which the mean outdoor temperature is below 55 degrees. The total of hours is based on half-time operation over a twelve-hour day during this period.

Where forced-circulation duct systems of warm air heating are used, the operating period for the fan is assumed equal to that of the heating plant, although in some systems, the fan runs continuously.

For estimating the cooling system, curve BB is used, representing the monthly mean temperature plus one-half of the average daily temperature variation. Since this daily variation is approximately 20 degrees in summer, it is assumed that the temperature will rise about 10 degrees above the mean during the daytime and fall about 10 degrees below the mean during the night. The limits of the cooling seasons are determined by the points where curve BB crosses the 70 degree line, representing a period of 3 to 3½ months for the Canadian cities. During the months of June and September, an ideal air conditioning plant might, therefore, be required to provide heating part of the time and cooling part of the time.

The maximum cooling effect which is considered desirable is shown in Table I. The recommendations of Table I may be approximated if the house is cooled by one-half the difference between outdoor temperature and 70 degrees. Evidently, 15 degrees cooling is about the maximum

TABLE I.
CONDITIONS RECOMMENDED FOR HOUSE COOLING
(A. S. H. V. E.)

Outside Temp. Deg. F.	Dry Bulb Deg. F.	Wet Bulb Deg. F.	Effec. Temp. Deg. F.	Relative Humidity Per Cent.	Grains of Moisture Per Lb. Dry Air
95	80.0	65.2	73.4	45.0	69.0
90	78.0	64.5	72.2	47.5	69.0
85	76.5	64.0	71.1	50.0	69.0
80	75.0	63.5	70.2	52.5	69.0
75	73.5	63.0	69.3	56.0	69.0
70	72.0	62.5	68.2	60.0	69.0

which would be required on the hottest days. In general, cooling equipment would not be used at night. Due to the relatively heavy house construction used in this climate, it seems fair to assume that the operating period would not be more than 6 hours per day. To provide the small degree of cooling normally required in Toronto (Fig. 1) a machine adequate for 15 degrees of cooling would usually operate intermittently, or at reduced speed and load.

Small cooling units are sometimes used to dehumidify the air, without producing any material reduction of temperature. The operating period for these units is assumed to be the same as that of house-cooling equipment.

In a recent book "Air Conditioning for Comfort," Mr. S. R. Lewis of Chicago, suggests the use of a fan to draw air through the attic of a house and so prevent the accumulation of heat from solar radiation. In cases where the cost of cooling equipment is not warranted, this scheme might improve summer conditions considerably, particularly in houses of the bungalow type. During a cooling season of 100 days, this fan might well be operated 12 hours per day for one-half the total number of days.

In contrast with Toronto, Figs. 5 and 6 indicate that Washington has a cooling season of 5 months and a heating season of 7½ months and that Los Angeles has a cooling season of 6½ months and a heating season of 7 months. It is obvious that the type of air conditioning equipment which would have the greatest value in Washington or Los Angeles would be quite different from that which would be most valuable in the Canadian cities.

Power Requirements of Air Conditioning Apparatus

Even among air conditioning equipments of a single type, there is a considerable variation in power requirement. However, an average figure may be established for each important class of equipment used, to serve as a basis for estimating the energy requirements of such apparatus for the operating season. It is also possible to designate the general types of electric motors which constitute most of this load, and to indicate the approximate power factor at which they operate. Summaries of this type have been prepared for Toronto and for Montreal. (Figs. 7 and 8). Of course, these data cannot be taken to represent accurately the energy consumption for any specific make of equipment.

Fig. 9 represents the monthly requirements of electrical energy for air conditioning a house of average size in Toronto. The summer load is based on cooling two rooms, rather than the whole house. It is possible to design the equipment so that cooling may be applied to living rooms during the day, and to bedrooms at night. The demand for partial air conditioning plants of this kind will undoubtedly be more important in the near future than the market for full capacity equipment.

Cooling with Ice

Considerable progress has been made in cooling offices, restaurants, etc., by ice storage systems, particularly

Equipment for House Air Conditioning	Typical Elec. Load	Watt Input	Approx. Power Factor	Estimated Operating Season	Tot. Hrs.	Kw-hr. per Season
Domestic Oil Burner or Oil Furnace	⅛ h.p. split phase motor for blower and oil pump. Controls and ignition	200	60%	Sept. 1 to June 15	1860	372*
Automatic Gas Furnace	The majority of these do not use forced draft. Hence elec. power requirement is negligible.					
Automatic Coal Stoker	1/6 h.p.split phase motor, driving stoker mechanism and blower. Control devices.	250	65%	Sept. 1 to June 15	1860	465
Humidifier (with motor-driven fan)	Motor (Not economical to use elec. power to furnish heat)	50	50%	Oct. 1 to May 15	1350	67.5
Dehumidifier (small cooling unit)	½ h.p. capacitor motor driving compressor	600	90%	June 1 to Sept. 15	125	75
House Ventilating Fan	1/6 h.p. split phase motor	225	65%	June 1 to Sept. 15	600	135
Air Distribution System for heating with a duct system	¼ h.p. split phase motor with controls	300	70%	Sept. 1 to June 15	1860	558
Cooling Equipment and Air Distribution (a) 2 rooms or one average sized office (1.5 tons);	3 h.p. total. Capacitor motor used for driving compressor	3000	90%	June 1 to Sept. 15	125	375
(b) 8 room house of average construction (4 tons)	7½ h.p. total. Polyphase motor used for driving compressor	7000	80%	......	....	875

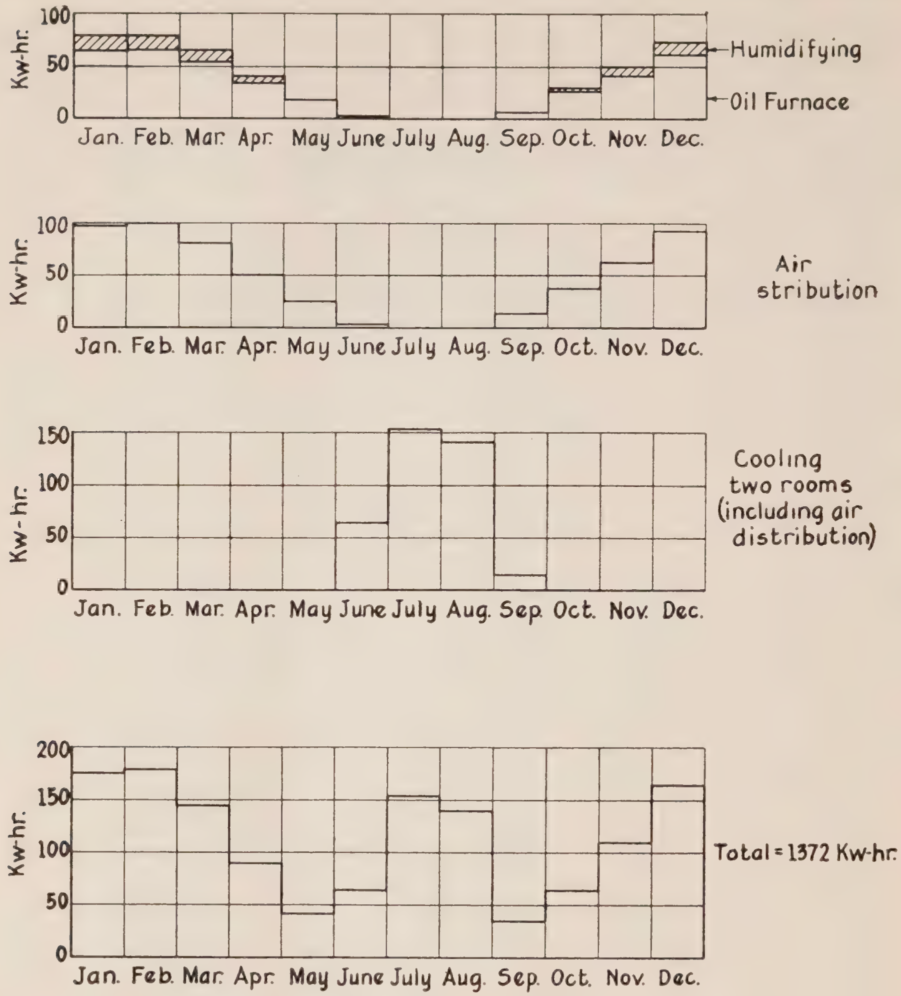
* If the furnace is in use all year to heat service water, this figure may be increased by about 25%.

Fig. 7.—Typical Energy Requirements of Home Air Conditioning Equipment in Toronto.

Equipment for House Air Conditioning	Typical Elec. Load	Watt Input	Approx. Power Factor	Estimated Operating Season	Tot. Hrs.	Kw-hr. per Season
Domestic Oil Burner or Oil Furnace	1/8 h.p. split phase motor for blower and oil pump. Controls and ignition	200	60%	Aug. 20 to June 15	2090	418**
Automatic Gas Furnace	The majority of these do not use forced draft. Hence elec. power requirement is negligible.					
Automatic Coal Stoker	1/6h.p. split phase motor, driving stoker mechanism and blower. Control devices	250	65%	Aug. 20 to June 15	2090	522
Humidifier (with motor-driven fan)	Motor. (Not economical to use elec. power to furnish heat)	50	50%	Sept. 20 to May 15	1405	70
Dehumidifier (small cooling unit)	1/2 h.p. capacitor motor driving compressor	600	90%	June 1 to Sept. 5	90	54
House Ventilating Fan	1/6 h.p. split phase motor	225	65%	June 1 to Sept. 5	558	126
Air Distribution System for heating with a duct system	1/4 h.p. split phase motor with controls	300	70%	Aug. 20 to June 15	2090	627
Cooling Equipment and Air Distribution (a) 2 rooms or one average sized office (1.5 tons);	3 h.p. total. Capacitor motor used for driving compressor	3000	90%	June 1 to Sept. 5	90	270
(b) 8 room house of average construction (4 tons)	7½ h.p. total. Polyphase motor used for driving compressor	7000	80%	......	....	630

** If furnace is in use all year to heat service water, this figure may be increased by about 25%.

Fig. 8.—Typical Energy Requirements of Home Air Conditioning Equipment in Montreal.



Typical Annual Load Chart
for
Air Conditioned House
(Toronto, Ont.)

(2 rooms cooled in summer: oil burner heating)

Fig. 9

where the cooling season is short. Since the manufacture of ice requires the use of 40 to 60 kw-hr. per ton of ice produced, this development should be of particular interest. Although the cost of ice (approximately $3 a ton) involves a somewhat higher operating cost than that of the mechanical refrigerating plant with average power costs, the initial cost of the installation is much lower, particularly where only a small ice melting capacity is required per day and the storage volume is not

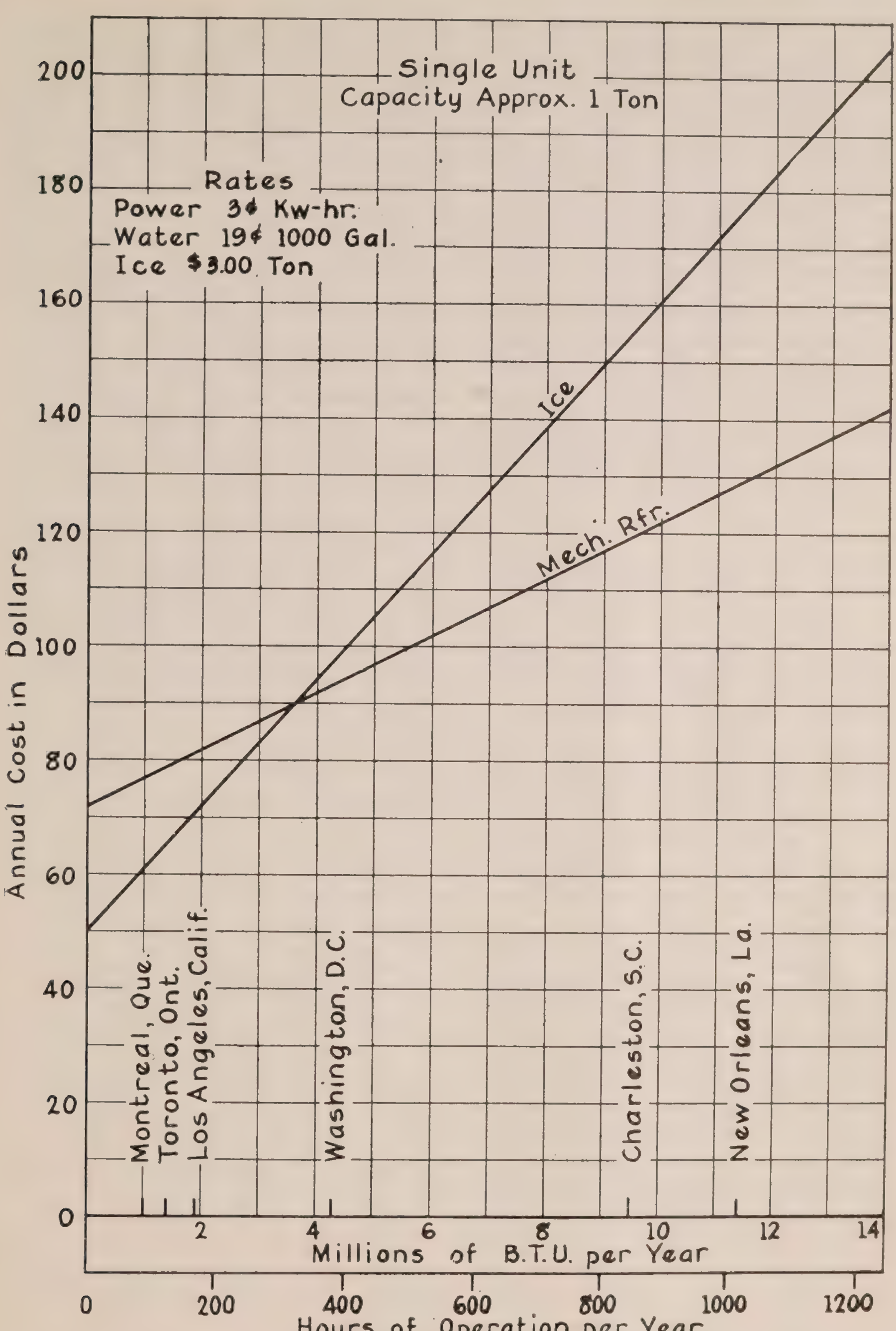

Single Unit
Capacity Approx. 1 Ton
Rates
Power 3¢ Kw-hr.
Water 19¢ 1000 Gal.
Ice $3.00 Ton
Ice
Mech. Rfr.
Annual Cost in Dollars
0
20
40
60
80
100
120
140
160
180
200
Montreal, Que.
Toronto, Ont.
Los Angeles, Calif.
Washington, D.C.
Charleston, S.C.
New Orleans, La.
2
4
6
8
10
12
14
Millions of B.T.U. per Year
0
200
400
600
800
1000
1200
Hours of Operation per Year

Fig. 10

prohibitive. Fig. 10 compares the cost of operating mechanical refrigeration plants and ice storage plants having a capacity of one ton of refrigeration* in 24 hours. In this comparison the first cost of representative equipment has been included in the operating cost for a 10-year period, with interest charge at 6 per cent. The result shows that, for the short cooling season normally found in this territory, the overall cost of the ice storage system is less than that of mechanical cooling equipment. For larger capacities, the comparison becomes less favourable to the use of ice.

THE MECHANICAL HEAT PUMP FOR HEATING AND COOLING

During the past two years there has been considerable interest in the idea of using a refrigerating machine as a means of cooling in summer and also for heating in winter. This possibility was first suggested by Lord Kelvin[1] in 1852, and has been the subject of several more recent papers[2,3,4,5,6].

The principle involved is exactly the same as that of the domestic refrigerator, which is really a heat pump. In the domestic refrigerator, heat is removed from the cabinet at a temperature of 50 degrees or less, and is dissipated to the room at a higher level, say 70 or 80 degrees. Actually, the condenser of the refrigerator runs at a considerably higher temperature, to permit easy dissipation of the heat to the surrounding air. In a house cooling plant, heat is removed from the house at 70 or 80 degrees and is discharged to the outdoor air which may be at 95 degrees. Similarly, a refrigerating machine can be used to absorb heat at low temperature from the outdoor air in winter, and discharge this heat inside the house at a higher temperature, to heat the house. This is naturally a subject of great interest to the Electric Utilities, since it involves the use of the same motor-driven compressor and auxiliaries, winter and summer, and would consume a much greater amount of energy than any of the other air conditioning equipment which has been discussed. The possibilities and limitations of this system will therefore be discussed in some detail.

The capacity of such an equipment, for use in Canada, would be determined entirely by the heating requirements. The cooling requirements would be so small in comparison that it would be necessary to run the machine at greatly reduced speed in

* 288,000 B.t.u. in 24 hours, or 12,000 B.t.u. per hour.

[1] Thomson, William (Lord Kelvin), "On the Economy of the Heating and Cooling of Buildings by Means of Currents of Air," Glasgow Phil. Soc. Proc., v. 3, Dec., 1852.

[2] Stevenson, A. R., Jr., "Cooling Homes, A Field for Refrigeration," presented at the symposium of the Refrigeration with Gas Committee of the American Gas Association, April 20, 1926.

[3] Haldane, T. G. N., "The Heat Pump—An Economical Method of Producing Low-grade Heat from Electricity", Electric Review, v. 105, pp. 1161-1162, Dec. 27, 1929 and I.E.E. Journal, v. 68, pp. 666-675, June, 1930.

Haldane, T. G. N., "Reversed Refrigerating Cycle for House Heating," Electrical World, p. 782, April 25, 1931.

[4] Doolittle, H. L., "Edison Building Heated and Cooled by Electricity," Power, v. 74, pp. 348-351, Sept. 8, 1931.

[5] Stevenson, A. R., Jr., F. H. Faust, E. W. Roessler. "Application of Refrigeration to Heating and Cooling of Homes", G. E. Review, March, 1932.

[6] G. Wilkes and R. E. Marbury, "House Heated by Pump with 5 to 1 Pick-up Ratio," Electrical World, Dec. 17, 1932.

summer to obtain anything like continuous operation. For winter heating, the capacity must be sufficient to raise the house temperature 80 or 85 degrees above the outdoor temperature in severe weather, whereas the summer cooling capacity need only be enough to maintain the house 15 degrees below the outdoor temperature.

The performance of a refrigerating machine, whether used for heating or for cooling, is indicated by the "coefficient of performance".

Amount of Heat Transferred
Heat equivalent of electrical input (to the driving motor)

Since the coefficient of performance of the heat pump varies greatly with the operating conditions, any statement as to its practicability for house heating must take account of the operating temperatures. The electrical input to the driving motor is determined by the compression range through which the refrigerant must work and, this in turn, is determined

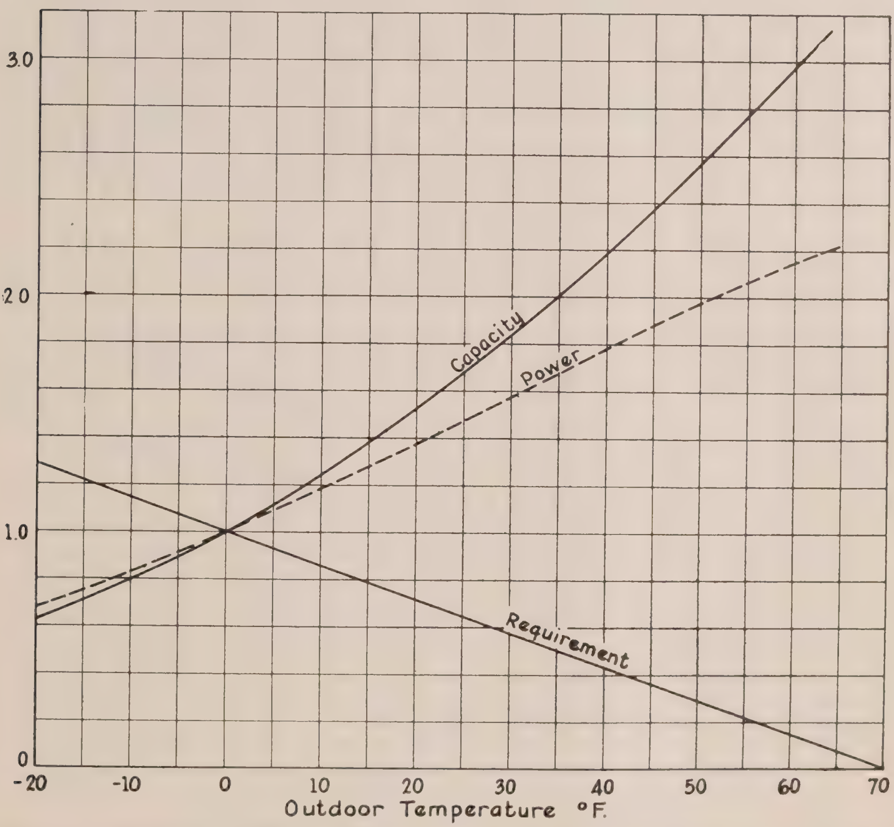


Fig. 11.—Variation of Heating Requirement and Heat Pump Input and Capacity with Outdoor Temperature. (Normal capacity at zero outdoors with 150 degree condenser).

by the temperature differences between the evaporator and condenser. High condenser temperature and pressure increase the energy input per unit of heat delivered. The capacity of the machine decreases rapidly, and the energy input per unit of heat output increases very rapidly as the evaporator temperature, (dependent upon outdoor temperature) is reduced. Fig. 11 shows the variation in capacity of this machine as a heating equipment, for various outdoor temperatures, in comparison with the heating requirement of a house at the same temperatures, the "design point" being taken as zero degrees fahr. For temperatures below the "design point", the capacity of the heat pump decreases just when the greatest heating capacity is needed. Therefore, the equipment would have to be designed with a capacity adequate for the coldest weather. In milder weather, where the machine capacity is greater and the heating requirement is less, the heat pump would operate intermittently or at a greatly reduced rate.

For Fig. 11, a condenser temperature of 150 degrees has been chosen. Admittedly, this is unfavorable to the heat pump, but the use of any lower temperature for the house heating source would make the heat distribution problem very difficult for any building in a severe climate. Even 150 degrees temperature of the heat source would scarcely be adequate for a warm air system in a severe climate, but this figure has been chosen since it could be adapted to a hot water heating system without resulting in radiators of excessive size

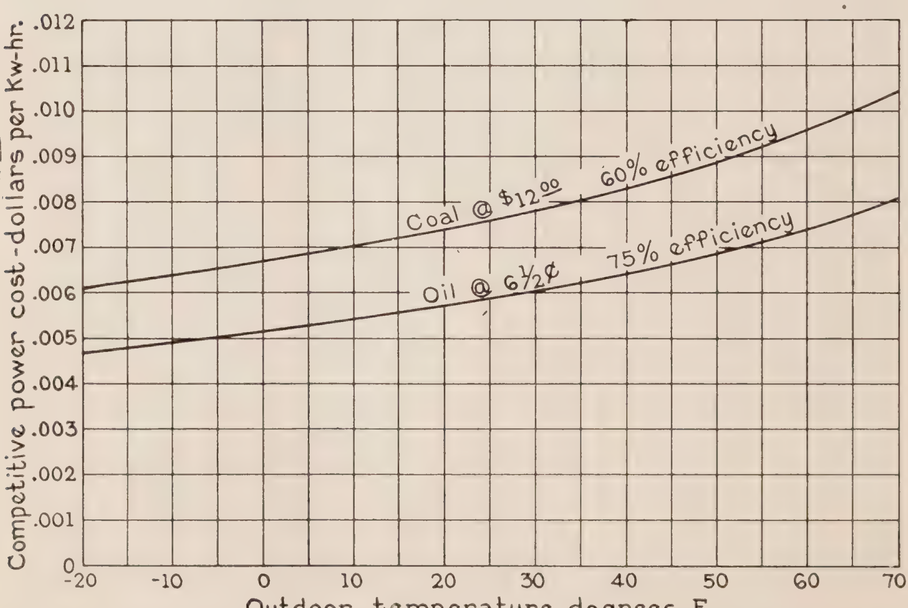


Fig. 12.—Power Rate for Heat Pump, with 150 degree Condenser to equal Fuel Cost of Coal or Oil Heat.

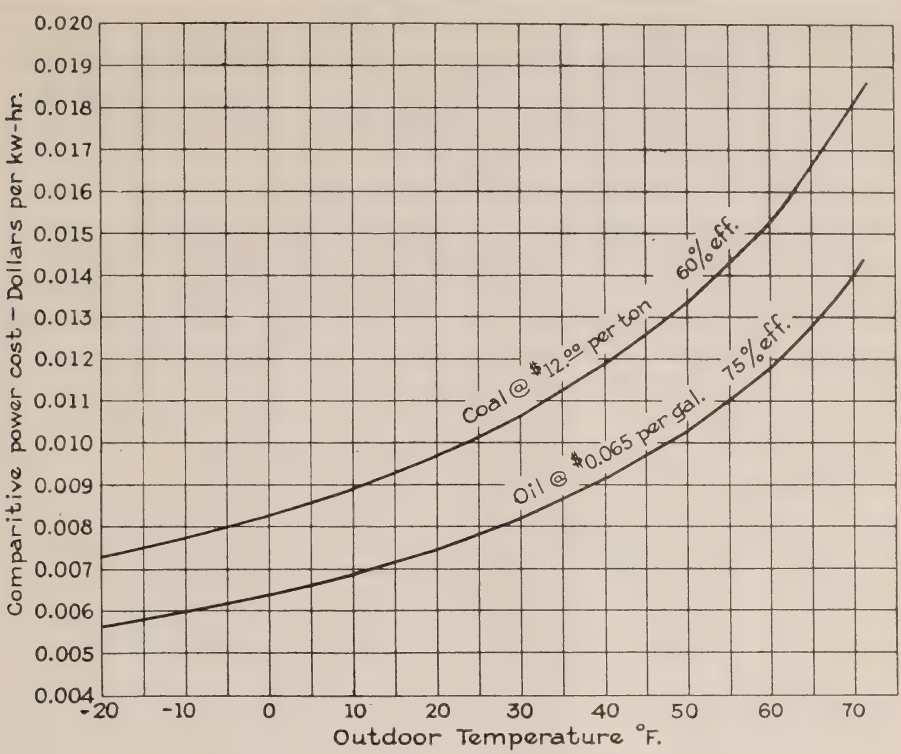


Fig. 13.—Power Rate for Heat Pump, with 100 degree Condenser, to Equal Fuel Cost of Coal or Oil Heat.

and since it was not intended to penalize the heat pump in this comparison.

If this machine were installed in a warm climate, where outdoor temperatures were normally above 30 degrees, it might be feasible to heat a building with air heated by the condenser to only 100 or 110 degrees, since the heating requirement would be small and the volume of air required to convey the heat would not be excessive. For this reason, the data presented by Stevenson[5] were based on 110 degrees condenser temperature. It might also be possible to use a lower heating temperature, such as 100 degrees, if large sections of the exposed walls were designed for use as heating panels. This system does not appear suited to summer cooling, due to the possibility of condensation when the walls are cooled, and requires special house construction, even for heating. Hence, panel heating is not at present a common method, but it remains as a possibility.

Figs. 12 and 13 have been prepared to indicate the power rate which would be necessary to bring the energy cost of the heat pump in line with modern coal—and oil-burning equipment. Although the variations in fuel costs for different localities will affect this comparison, the efficiencies used are now obtainable as overall values for the heating season, with

automatic house-heating equipment. To obtain the cost of heat pump operation for the winter, it would be necessary to integrate the results of cold weather and mild weather operation, since the coefficient of performance of the heat pump varies so greatly with temperature. Depreciation, amortization, and maintenance have not been considered in preparing Figs. 12 and 13. In general, these items would be greater for the heat pump than for the oil- or coal-fired heating plants.

It should be remembered that this is not an off-peak proposition, and that it would be difficult to build a heat pump system to operate only on off-peak rates during the night. Off-peak systems require the storage of heat at comparatively high temperatures, whereas, a high condenser temperature is inherently unfavourable to the heat pump. For the climate of Los Angeles, (Fig. 6) the heat pump appears to be a practical means of heating, since the outdoor temperature very seldom drops to 30 degrees, and one large installation in Los Angeles has been in successful operation for over two years. However, for the climate of Ontario, the heat pump does not appear to be economically justified unless power can be supplied at very low rates.

Conclusion

The load building possibilities of air conditioning for the home and for small commercial establishments may be summarized as follows:

In most cases the energy consumption is not large in comparison to the size and cost of the equipment which the user must install. In the northern climates motor-driven heat pumps, which would have the largest electrical input, appear to have only a limited market for house cooling, and practically no market for house heating. However, the improvements in living comfort which are being made possible by the various phases of air conditioning, all point to a wide-spread use of air conditioning equipment in the various forms best suited to the climatic conditions. In the aggregate, these devices will ultimately constitute a desirable and important source of load to the Electric Utilities.

Entrance to Toronto-Leaside Transformer Station.

THE
BULLETIN

Published by
HYDRO-ELECTRIC POWER COMMISSION
of Ontario

190 University Ave.
Toronto

Subscription Price $2.00
Per Year

Mere Distribution

By S. M. Dean, Chief Assistant Superintendent of Electrical System, The Detroit Edison Company, Detroit, Mich., prepared with the assistance of Harold Cole and H. P. Seelye.

(*Presented to Association of Municipal Electrical Utilities at Toronto, January 25, 1933*).

GENERALLY speaking, electrical distribution systems have to date been like the weather in that while much is said about them comparatively little has been done. It is, therefore, the purpose of this paper to show the relative importance of the distribution system and to suggest ways of improving its usefulness at minimum cost.

Distribution system engineering, construction and operation differ in a number of essential respects from other electrical engineering and these aspects will be considered.

Without doubt there will be disagreement with some of the methods proposed but, if this paper results in the development of a more accurate understanding of the means at our disposal, it will have served its purpose.

The General Investment Picture

Fig. 1 shows the total investment in each of the major branches of Central Station Industry in the United States from 1920 to 1931. From this chart you will note that at the present time there is invested in the Central Station business some 12¼ billions of dollars which is divided approximately as follows:

Power Plants	4-7/10 Billions
Transmission	1-8/10 "
Substations	1-5/10 "
Distribution	2-8/10 "
General Purpose	1-4/10 "

Of the 2-8/10 billion dollars invested in distribution, it is estimated that some 2¼ billions is in simple radial overhead lines, *and for these approximately ten cents of every dollar income must be set aside to pay*

CONTENTS

Vol. XX **No. 2**

February, 1933

interest, depreciation, maintenance and taxes. From Fig. 1 you will also note that it is growing slightly faster than any other major item and is indeed very conspicuous in the total.

It is in the interest of these lines, so often considered beneath the dignity of the electrical engineer, and, therefore, left to the discretion of the linemen, that I wish to speak.

As an investment item, they rank with power plants and are not to be compared to transmission and substations, yet great thought is given transmission and substations, and rightly so; whereas, distribution is largely out of sight and, therefore, often out of mind. The calamities which befall it are commonly passed off as "Acts of God," and if God be acting particularly badly, the glib and expensive answer of "network" is given as the remedy, whereas there are, in fact, a number of much less costly modifications of simple overhead radial distribution which may be adopted with remarkable improvement in reliability and quality of service. So much concerning the importance of distribution.

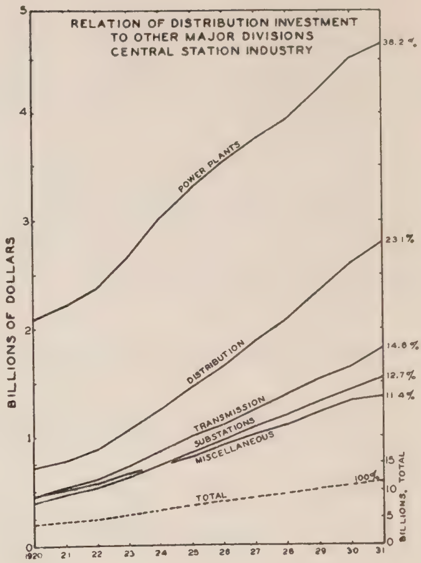


Fig. 1

PROBABLE REQUIREMENTS OF THE NEXT DECADE

It has been variously estimated that by active sales effort the annual electricity consumption of domestic users can be increased three to five fold. Obviously, such an increase must in large part come from added utilization devices, such as, electric ranges, water heaters, oil burners, household refrigerators, improved lighting, etc. It also is quite certain that commercial loads will increase due to better lighting, air cooling and ventilating equipment, and the like.

This increased use of electric service implies increased dependence upon it, for the user will be much less tolerant of a spoiled dinner or a cold house than he now is of an occasional outage of lighting service—as like as not occurring during daylight hours. Therefore, the most important demand on radial distribution will

FREQUENCY DURATION AND CAUSES OF INTERRUPTION TO AVERAGE LIGHTING CUSTOMER

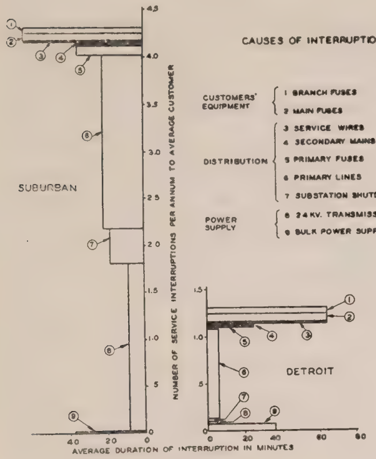


Fig. 2

probably be that of *increased reliability.*

If electric ranges are to compete with gas, it is important that they heat up and cook rapidly and that implies good voltage regulation. Good regulation is also important to all other devices but it is probably more so to heating devices. Therefore, a second requirement will probably be *improved voltage regulation.*

There is also the saving to be made in the proper and intelligent proportioning of *distribution transformer size and spacing, against quantity of secondary copper.* This involves the moot question of *losses* and what, if anything, should be done about them.

There is also the problem of how much may be invested in *protection* to save the cost of replacing burned out transformers and fuses and replacing lines down, quite aside from the dictates of reliability.

The design of the line structures themselves, and the *control of construction,* stocks, etc., is a very important factor which will demand attention.

Let us consider these requirements in order.

Improved Reliability

The first and most important step in considering improved reliability is a thorough knowledge of the causes of long time outages (one minute or over) and just whose service is, in fact, impaired by them. An accurate study of operating records of The Detroit Edison Company brought forth the very interesting and pertinent facts shown in Fig. 2. This chart shows, for both the city and the suburban systems, the total number and duration of outages to the average customer, by causes, from power plant failures to and including the failures of the customers own equipment as indicated by blowing of his main and branch circuit fuses.

From the viewpoint of distribution, these so-called "long outages" fall into the following groupings by causes:

1. Loss of source of power. (Power plant and transmission).
2. Failure of distribution substation or equipment.
3. Outage of all or part of distribution circuit due to primary grounds or wires down or both.
4. Outage of distribution transformers due to both blown fuses and burnouts.
5. Secondary troubles. (Negligible for overhead construction).
6. Failures on customers' premises.

To properly interpret these outages, account should also be taken of the

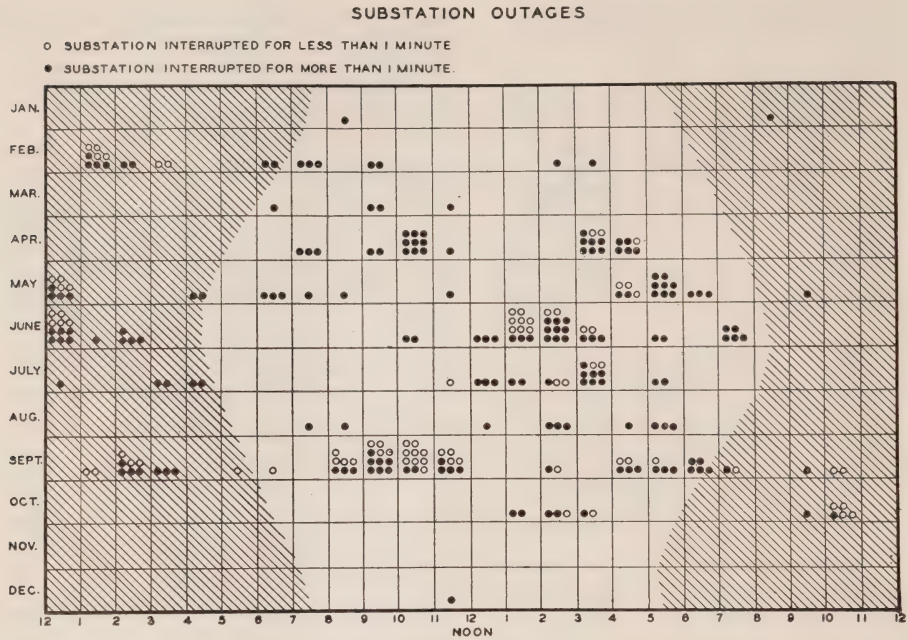


Fig. 3

time at which they occur and the length of time required to restore service, both for casual outages and for conditions prevailing during heavy widespread storms.

Fig. 3 shows a typical study chart of suburban substation outages due to 24 kv. wood pole transmission failures plotted, by months, against time of day. The solid circles are long outages (one minute or more). The most important fact is the almost total absence of long outages during the lighting period—darkness to midnight.

Similar charts prepared for 4,800 volt distribution (covering several years) show no regularly recurring concentration of outages at any time of day.

It is, therefore, evident that, while it may be necessary in some cases to give added protection to important power customers, we can neither afford to increase the insulation of our 24 kv. transmission lines nor install additional 24 kv. switchgear, to further protect lighting customers. On the other hand, we should give careful thought to what may be done to reduce distribution line outages, particularly in our suburban territory.

Distribution Substation Outages

Distribution substation outages are largely due to failures caused by lightning originating on overhead lines. Such outages average thirty-six minutes but they are often many times that long and are therefore serious. While ability to protect against such outages is a problem in insulation coordination, it has been our experience that the real problem is that of securing bushings that will not allow moisture to leak in or otherwise lose their insulating value. We

have found that for our sub-transmission line insulation levels (33 kv. class), a standard 24 kv. transformer protected by a proper lightning arrester will very rarely cause trouble.

On the distribution side we have found that bushings and other insulation of the 7,500 volt class protected by a proper lightning arrester near the cable pole and another at the induction regulator line terminals, gives entirely satisfactory results except for the bushings. The principal problem is again that of bushings which will not deteriorate with age. We believe the bushing problem is being solved but only time will tell.

Primary Outages

Referring again to Fig. 2, a comparison can be had of the number and duration of outages due to primary failures occurring in the city and those occurring in suburban territory. You will observe that there are two and one-half suburban outages to one in the city. This results from two causes. We use ringed primaries in city and radial in the suburbs. Inherently, the city circuits have less exposure and much less length per customer, but this is to some extent counter-balanced by the larger number of customers affected by a single outage.

There are several means of attack on outages due to primary grounds and burndowns, some of which have the sanction of experience and others which, though untried, show promise.

On the grounded neutral system, which is by far the most common, short circuits, due to tree grounds and burndowns due to foreign materials over the lines, are the most prevalent sources of primary outage. Experience seems to indicate that the best grades of tree wire merely "postpone the evil day" when grounds will occur, and it therefore, seems to me that the ungrounding of the neutral is the practical answer to the question of ground outages and should almost entirely eliminate them.

One aspect of this proposal should be investigated more fully and that is the operation of 4,000 volt ungrounded neutral systems using standard 2,300 volt apparatus. This has been done for several years by one large operating company but its implications should be thoroughly understood.

In considering an isolated neutral system, it should be remembered that its use implies, for unattended substations, a ground alarm system. Such a system is not particularly complicated or costly and has proved very satisfactory in the case of The Detroit Edison Company.

It has been argued that the use of single pole switchgear on a grounded neutral system confines outages due to grounds to one phase and will therefore materially reduce such outages. The cost of such switching is high and the occasional operation of motors on two phases is not desirable. This practice seems to be giving way to the three pole breaker.

In cities and elsewhere where conditions and costs permit, an ungrounded neutral together with either "ringed primaries" or "double end" primary feeds to offset burndowns due to foreign materials across the lines will practically eliminate primary outage.

The following is an analysis of the effect of broken primary wires, based

on the 1931 operating record of 220 city circuits having ungrounded neutral, ringed primaries and banked secondaries. It will serve to show what results may be obtained from these practices.

Total cases of broken wires	293
Long interruptions (30 minutes or more to total circuit or major part of circuit)	10
Long interruptions to minor part of circuit (5 transformers or less)	46
*Short interruptions (1 minute or less)	44
*No interruptions	193
	293

* Of the 237 cases covered by these two items, 120 are the result of ringed primaries, 104 the result of banked secondaries, and 13 were on dead ends serving no transformers. On a radial primary system not employing banked secondaries, 224 of these cases would have resulted in an interruption varying from a single transformer to the major part of the circuit.

In suburban and rural territory where ringed primaries and therefore banked secondaries are usually impractical, an ungrounded neutral goes a long way in reducing primary outages. I regret that I do not yet have an operating record for these radial suburban circuits—similar to that given above for the ringed primary city circuits. Fig. 2 will give comparative performances per customer.

A new development shows some promise of coming into the picture and that is a satisfactory insulated wire for overhead primaries. Sooner or later this problem will be solved and when such wire is available, it will offer a practical and simple means of preventing burndowns on these long suburban circuits and on other circuits where "primary rings" or "loops" are hardly practicable. In the meantime, all angles of the use of insulated wire should be thought out, particularly the political liabilities involved which centre around safety considerations. Of late there seems to be less violent objections to the use of insulated wire which is a hopeful sign for it should prove a powerful and inexpensive aid to improved reliability.

Distribution Transformer Outages

Distribution transformer outage is due either to fuse blowing or burnouts, both of which are largely caused by lightning. At present there is but one practical method of eliminating this form of outage and that is to parallel and fuse the transformers on both the primary and the secondary. Until thoroughly reliable insulated wire is available, this "banking" to be safe, must be done on a ringed primary and the "banks" must be carefully designed as to size and location of transformers and accurately fused if it is to operate without "cascading." Furthermore, they must be regularly checked for fuse blowing and loading. If a company is not prepared to take proper care of these banks, they should not be undertaken. Also, when streets and alleys are "jumbled" in disorderly array or the circuits are very long and lightly loaded, this practice is often out of the question. It must be said, however, that when combined with proper

lightning protection and properly handled this practice is very effective. It also gives much improved voltage regulation as will be brought out later.

Studies of the two hundred and twenty city distribution circuits of The Detroit Edison Company, which employ "banked" transformers, indicates that in 1931 there were some two hundred cases of fuse blowing and transformer burnouts, almost none of which resulted in customer outage. Fig. 2 also shows the effect of this practice.

The proper lightning protection of transformers is most important, particularly where "banking" is not employed. The practice of shunting the arrester across the transformer and grounding it to the secondary neutral gives promise of material reduction in fuse blowing and transformer burnouts with a very decided improvement in service. It seems quite certain that code difficulties will be solved and this practice generally adopted. I would, however, sound a note of warning in that this common ground practice should be carefully co-ordinated with rural customers' neutral grounding in barns and out-buildings, where a municipal water system or equivalent good ground is not available.

It should be remembered that even the best of lightning protection is hardly a substitute for transformer "banking", that being almost perfect protection against loss of service due to transformer outage.

The recently developed overhead secondary network offers another means of eliminating service outage due to distribution transformer failure by duplicating the primary feeder and the distribution transformers, but it also requires that each transformer be equipped with a costly and complicated network protector. It seems to the writer that, if the adaptations of radial feed described above are carried out, the much higher cost and the complication of the overhead network will not be necessary except where the primary feeders must be wholly or in large part underground.

Secondary Troubles and Failures on Customers' Premises

Since secondary troubles are practically negligible on overhead systems and failures on customers' premises are factors largely beyond our control, discussion of them is omitted.

Voltage Regulation

Far too little is known about actual steady state and flicker voltage requirements. Too often the standards are set with scant regard for the cost and the practical limitations of voltage regulation. Obviously, no single set of standards will apply to all classes of service or to all companies and much discretion must be exercised in applying any voltage limits or flicker rules. Fundamental to an appreciation of the problem and the intelligent application of standards is an understanding of where the voltage drops occur, and their amounts, and what means are available to counteract them. It must be understood that there will be one to one and a half volts drop in service wires, often two to three volts in the secondary mains, and two to three volts in the transformer. These factors alone absorb some six volts of the allowable range. With this must be combined the drops to be encountered

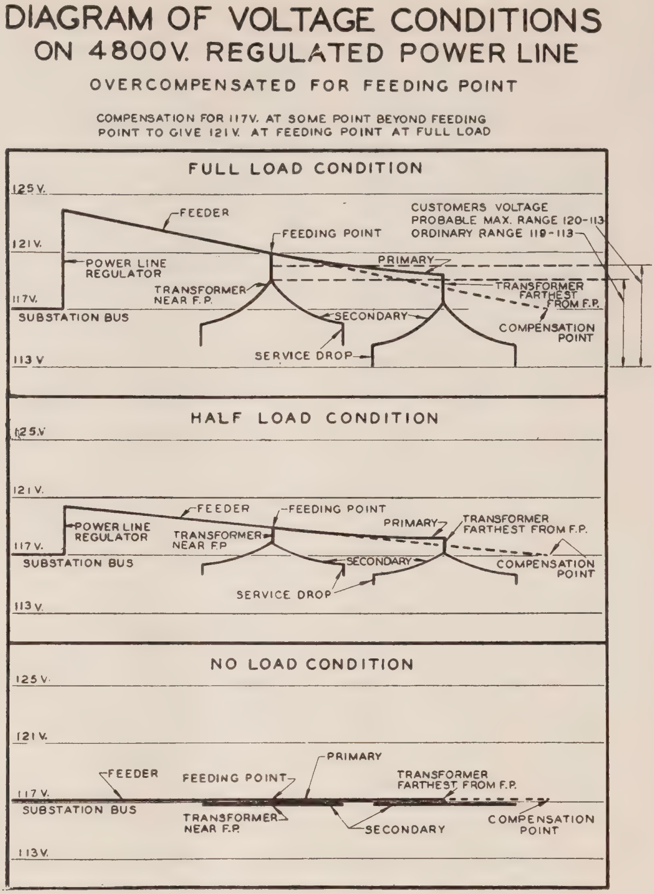


Fig. 4

in the chosen primary system as influenced by regulator compensation and the voltage range of the source bus. From these figures there becomes apparent other reasons than reliability which influenced our choice of a feeder and "ringed primary" system with "banked" transformers. These show a return in voltage regulation as well as reliability.

Fig. 4, illustrating voltage regulation methods as we use them, has proven useful in Detroit in clarifying this picture and in demonstrating to others not intimately associated with distribution work the inherent limitations encountered. It is not complete in that a properly applied induction regulator "bucks" at no load but it does serve to illustrate. I believe that a thorough "talking out" of the voltage limits and flicker standards now in use by the operating companies would be a most profitable undertaking. To be sure no single set of limits will be found to apply to all companies or to all classes of service within the companies, but a more thorough understanding of them

cannot be other than enlightening and profitable.

Transformers and Secondary Copper

An important problem is the choice of the most economical combination of transformers and secondary copper. When it is considered that thirty per cent. of the 2-8/10 billions of dollars invested in distribution in the U.S.A. is in transformers and secondary copper, the importance of being right in this matter can be appreciated.

On the Detroit system we decided, after some study, that we would plan our service to the better residential districts on the basis of an electric range for every customer. This gave a probable loading of 75 kv-a. per 1,000 ft. of secondary. With this load as a basis and the assumption of "banked" transformers, the most economical secondary size proved to be No. 2 copper and the best transformer spacing about 600 ft. Fig. 5 shows, in solid black, the cost curve on which this decision is based. This combination also proved adequate for appliance motor starting. Because of the difficulty of replacing secondaries, it was decided to install No. 2 wire initially, hang the transformers in their permanent locations, and increase transformer sizes as the load grew. That method is proving to be practical as well as economical and therefore has the support of overhead lines construction people—a very important consideration.

It might be argued that the installation of No. 2 secondary well in advance of requirements is uneconomical with present day reduced load growth and low priced copper. The dotted total cost curves in Fig. 5 are based on a load density of 30 kv-a. per 1,000 ft., which approximates that of well built up residential territory, and 75 kv-a. per 1,000 ft. which is very heavy density, and both are on the basis of ten cent weatherproof wire which is slightly below present day prices. The 30 kv-a. condition would justify No. 4 wire but No. 2 wire comes very close to qualifying. The 75 kv-a. condition would justify No. 0 but again No. 2 is about as good. It is therefore evident that widely varying conditions cause little change in secondary copper size. These curves are now being revised to take account of losses but we are inclined to feel that this change will not greatly alter the conclusions.

The fundamental involved is that for a given load density and voltage regulation, the quantity of secondary copper varies approximately as the

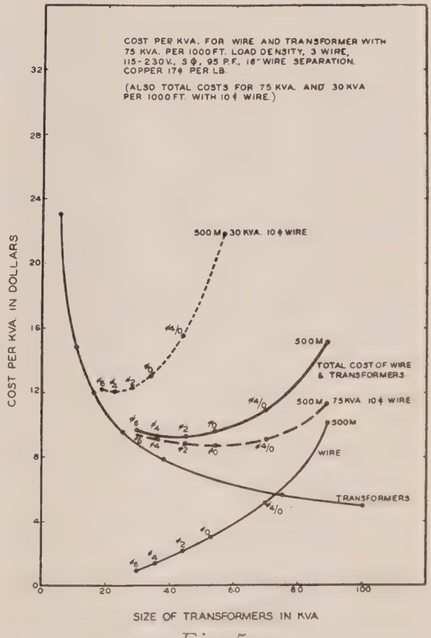


Fig. 5

square of the distance between transformers. On the other hand, the total kv-a. of transformers to serve a given load density is the same, the only saving being in the larger transformer size employed and the reduced number of transformer mountings.

The question of how much money may profitably be spent to reduce losses in the distribution system is one that is arousing considerable interest, and the impression seems to be current that considerable money might profitably be spent to that end. However, I should want to be shown that it is wise to spend more than is necessary to meet voltage regulation requirements, in an effort to reduce losses. I do not know the answer but the problem is one that should be pursued to some conclusions.

Protection Costs

Just as a matter of return on investment, how much can we afford to spend to prevent transformer burnouts and fuse blowing? Based on actual operating records and some experimental installations in Detroit, we can afford to install a proper lightning arrester and a low resistance combined secondary and arrester ground on the more exposed transformers on our system and completely pay for them in some seven years, not to mention a marked improvement in service, particularly on rural and suburban lines. This is a fit subject for thought.

The problem of eliminating distribution transformer burnouts and fuse blowing is now beginning to receive the attention it merits, and the practice of shunting a proper arrester across the transformer and fuses gives promise of real protection at not unreasonable cost.

Construction Standards

The construction of distribution lines partakes of many of the characteristics of mass production. It consists of small jobs so numerous that it is impracticable to accurately supervise each of them and yet the aggregate is so large that loose methods are very costly. Therefore, one of the first jobs of the Distribution Engineer is to standardize his materials and to prepare specifications covering their use. The rewards in reduced construction costs, both material and labor, are well well worth going after. In one company the original study resulted in a reduction of fifty per cent. in items of overhead lines stock and appreciable further reductions were made later.

Another cost saving could be made if a better agreement could be reached among distribution engineers on standards for line materials. This activity is being carried out in Committee, but I believe the standardization is considerably in advance of the use being made of it by operating companies.

Another very real source of savings is the engineering of each particular job that goes in. This means that the distribution engineer must make available, preferably in loose leaf book form, the necessary electrical data and tables as well as the civil engineering data and tables, such as, pole and wire strength, sag tables, guying tables, etc., to enable the field engineers as well as the construction

people to intelligently apply the specifications and standards to the wide variety of situations arising in the field. This field engineering for best results should be under the control and direction of the distribution engineer for the larger jobs and subject to his review on the smaller ones. Our experience has shown that a proper field engineer's data book goes a long way toward accomplishing this result.

WHAT HOPE OF REDUCED COSTS

Having done all these things as far as they are practicable, what hope is there of reduced costs?

In talking of costs, we must be specific. There is no simple and accurate physical unit of distribution which may be used as an index of changing costs. There are so many variables which are uncontrollable that it is impossible to analyze total investment to show just what savings have resulted from any one cause. The distribution engineer will have to content himself with showing the savings made on the more commonly used unit assemblies, such as, dead ends, transformer pole assemblies, reduction of stock items, reduced field labor due to simplification, etc. These savings, though often inconspicuous, are very real.

A summary of the larger factors influencing costs is as follows:

Those tending toward reduced costs—

1. Standardization of materials and their application should show an appreciable reduction over lines built at random.

2. The accurate engineering of transformers and secondary copper should show a very real saving.

3. The intelligent engineering of each construction job is important. Much money can be wasted by "rule of thumb" methods.

4. The intelligent differentiation between the requirements of city, village and rural service.

Those tending toward increased costs—

1. Any steps taken toward improved reliability and most steps toward improved voltage regulation.

2. The growing tendency of municipalities to force lines off main thoroughfares, often underground.

3. The blind following of fads and fashions in distribution practice without regard to the necessities of the case.

It seems probable that the factors tending to raise costs will more than offset those tending to lower them, and that will most certainly be true unless we are very careful to avail ourselves of all the advantages of radial distribution before adopting the much more costly multiple feed methods. However, we should not belittle the savings outlined because they may be outstripped by the increasing requirements. Those savings are very real and are a call to distribution engineering of the first order.

THE DISTRIBUTION ENGINEER'S PROBLEM

So far we have talked chiefly of the engineering of materials in distribution. There is another factor which, if it fails, will largely discount the effort put into material engineering. That factor is the very human one of convincing the lines construction departments of the fitness of your work,

and arousing their enthusiasm to the job of educating their foremen and line crews in the use of specifications, and in turn in becoming educated oneself by the very practical and useful contribution which they can make to the development of standards and methods. In a number of companies regular meetings of the line foremen are called to consider the problems of building lines to specification and to work out standard methods for doing each of the more common jobs. No one can better tell how a certain result should be accomplished than the man in the field. The result is an uniform practice throughout the entire field force, a very real "esprit de corps," and reduced labor costs. The importance of this aspect of the distribution engineer's work cannot be overstressed.

Summary

Summarized briefly, I should say the battle-front is as follows:

1. A very thorough study of actual operating records and a better industry understanding of the actual reliability requirements, and what practicable means of improvement are available. In terms of the individual distribution engineer, this consists of being very sure that actual operating experience will justify each move he makes, and that the implications of each move are thoroughly understood.

2. The same for voltage regulation and flicker limits.

3. A better understanding of the economics of transformers and secondary copper and of how far we should pursue the fetish of reduced losses.

4. More vigorous effort toward the standardization of materials and practices.

5. Study of the best ways to "sell" the field force on the "standards," and to avail ourselves of their experience and their cooperation. Very real savings are possible in labor costs and "esprit de corps" is the means which brings it about.

The Central Station's New Responsibility

By G. W. Austin, Manager, Electric Service League, Toronto

(Presented to Association of Municipal Electrical Utilities at Toronto, January 24, 1933.)

IN normal times, the growth of load for the Ontario Hydro System, and most of the local Hydros, occurs easily and in step with natural progress. Regular promotion work and processes of selling are sufficient. But these are not normal times. The upward curve of power consumption has halted, and a downward curve is showing in most cases. While local circumstances vary, according to community, the extent of industrialization, and other factors, it is now eminently clear that there is pressing need, more than ever, for vigorous central station activity to build up load. Losses have to be compensated for, rates must, if possible, be kept stable, and employment must be maintained. It is clear that the main contribution of new action toward load-building—and the creation of business for the electrical industry—must come from new forms and phases of central station promotion work.

It is, of course, not possible to determine what proportion of existing load has been built by selling activities of manufacturers, dealers, contractors, and other outside groups of the industry. For the purposes of this paper, it is not necessary to dig in detail into the relative contributions of the various groups. Apparently the major part of the domestic load arises from sales made on the initiative, and through the work of the non-utility groups. It is interesting to note that of the 1,500,000 appliances estimated to be in use by Hydro customers in Ontario, sales by Hydro shops in the five years 1925-29 inclusive were approximately 108,000 appliances. The point of raising this issue is to emphasize the interdependence of the utility and the other industry groups; and to demonstrate that every constructive, co-operative policy of the local utility that gives a helping hand to the other groups is, in essence, the height of self-service.

What are the requirements of the present situation?

The first is the initiation by the utility—where at present no such co-operation is being afforded—of a special department, or executive, charged with the responsibility of promotion and educational work. The local commission should take a broad view of this job, and its possibilities. It is easy to suggest a considerable number of difficulties arising from limitations on Hydro sales policies. But the need of such action is paramount, and ways and means can be found to get stimulative action without disturbing any hornet's nest. There is a tremendous untouched field for educational and promotion work by most central stations along lines that help, and do not conflict

with, the interests of the other groups. The point is that when manufacturers' and dealers' and contractors' sales of home electrical equipment have fallen so sharply, when new construction is negligible, and general wiring is greatly reduced, the wide and varied resources of the utility should be put more vigorously into play. The manufacturer and dealer sell but once. The contractor sells his wiring job but once. The revenue from their sales of appliances, lighting outlets and lamps comes into the utility year after year after year.

New Business Can Be Created

There is no doubt that a great deal of new business can be created, even in these times, by properly co-ordinated industry campaigns. No definite figures are available for wiring averages in the 600,000 Ontario homes, but we all know that in most houses more than six or seven years old, there is a terrible lack of wiring, according to present-day standard. The appliance saturation for Ontario, considering the cheapness of domestic current, leaves a great deal to be desired. At the end of 1931, according to figures from Mr. Mickler's department, the percentage of saturation for major appliances in Ontario was:

Ranges	26.4%
Hot Plates	12.7%
Washers	31.7%
Vacuum Cleaners	24.5%
Water-heaters	10%
Grates	5%
Air Heaters	32.7%
Ironers	1%
Irons	91%
Toasters	48.6%
Electric Refrigerators	7.8%
Grills	10.7%

Now at least 60 per cent. of Ontario's urban population—to which these figures apply in the main—have substantial buying power even at present. The use of motor cars shows little loss. Other forms of public spending, a great deal of it on luxuries, are fairly well maintained. The great problem in fresh selling of electric conveniences to the public is to make people want these things sufficiently, in comparison with other things. With the advantage of an extremely low domestic rate in Ontario, the present situation is both an invitation and a challenge.

As I have said, each Hydro utility in city or town should have a special promotion department or executive. The first task is to make thorough surveys of the local appliance and wiring conditions. Then through the lists and data thus obtained, there should be special educational and propaganda campaigns. These should not be only for appliances on sale in the Hydro shop, if there is one. A much broader basis, to make the educational and propaganda work apply to ranges, as a class or group; to water-heaters in general; to washers and cleaners in general, etc. should be developed. The "electric home" idea should be broadcasted. The public needs to be educated to regard the "electric home" as the modern ideal. The make-up of this electric home—what it consists of—should be hammered constantly into the public mind. Newspaper advertising, direct mail, literature of a general educative nature, lectures, schools, and demonstrations should all be used freely.

Check-ups of appliances in homes, to disclose what appliances are lacking, should be made regularly, and used as the basis of educational sales propaganda. Co-operation, along these lines, with the other appliance selling groups in the industry should be a cardinal principle. The economy of using household electric conveniences should be stressed, as well as their service merits. The central station promotion department should gladly receive constructive suggestions from the other groups for practical tie-in. If the Hydro utilities in Ontario cities and towns would apply a concerted determined drive in 1933, along the lines here suggested, in co-operation with the other groups, probably some millions of extra sales could be made, and a great gain in domestic load would be the gratifying result.

What apparently is the biggest opportunity of the utility in the promotion field has, in many cases, (Toronto excepted) been the most neglected. That is education of the public on *Adequate Wiring.* Adequate wiring is fundamental to all domestic load increase. It is the foundation of the lighting load. It is required before appliances can be used. Ranges, water-heaters, grates and other heavy conveniences must have special circuits. Yet many Ontario local managers seem to regard wiring as exclusively a contractor's affair. They practically wash their hands of it, in a promotion sense. True, the contractors usually try to keep the utility away from the wiring field. But even if wiring and wiring sales and development be justly regarded as the contractor's legitimate field, there are great possibilities for utility co-operation and assistance in this field—help which the utility can and should give to increase wiring, without creating fresh thorns in utility-contractor relations. It is extremely necessary that the contractors should have the aid of the central station by (1) educational campaigns to make the public realize fully what constitutes good wiring. (2) to educational work to emphasize good wiring installations as part of the "electric home" idea. (3) carrying on home lighting, modernization, and other campaigns that promote adequate wiring. The utility should take a broad view on wiring, for to increase wiring standards not only is good for the contractor and manufacturer, but comes home in dollars and cents in domestic load revenue. Consider that one extra lighting outlet, using a 40-watt lamp three hours a day, for 300 days, in half a million Ontario homes, is good for 60,000 kw-hr., per day. At 2 cents per kw-hr., this means $360,000 a year added revenue. Heavier services, more branch circuits, and more outlets—here is the foundation of increased domestic load. Here is the field in which educational and propaganda work can produce the biggest results, because this field has been the most undersold of all.

ADEQUATE WIRING BUILDS THE LOAD

It has been proven that *adequate wiring* leads to a tremendous increase in domestic load. The work of the Electric Service League in Toronto is probably the most outstanding example on the Continent—and in the world—of the value to the utility of a well-directed, hearty interest in better home wiring. The Toronto Hydro-Electric System has not hesitated to

give the League the strongest support, and the results obtained in the domestic, commercial, and industrial fields have assuredly justified it as a matter of cold business. Consider what has been accomplished by the Red Seal Plan in Toronto. At the end of 1932, there were 17,375 Red Seal Homes, consisting of 8,369 houses, 6,652 apartment suites, and 2,354 duplex suites. These are mainly homes erected in the last five or six years. The average number of outlets per house was 55.37, the average per room 8.02, and the convenience outlets per house, 12.90. All of the houses had 140 ampere, 180 ampere, or larger services; all had range wiring to kitchen (the basis of the sale of 10,000 extra ranges). The apartment suites each had electric ranges and refrigerators installed. Now contrast this, with the proven averages of non-Red Seal houses. The number of outlets in non-Red Seal houses, (new and old) averages 27.2, the room average 5.27, and convenience outlets per house 5.24. 72 per cent. of the non-Red Seal houses had 30 ampere services, 24 per cent. had 60 ampere, and 4 per cent. had 100 ampere. Roughly speaking, the Red Seal wiring job in quantity is just about *twice* as good as the non-Red Seal. The total number of outlets in Red Seal homes is 672,219. In carrying out this Red Seal plan, in which the League has also had the co-operation of a large group of Toronto contractors, the League staff makes about 30,000 inspections, calls and contacts annually. The percentage of new Red Seal homes against new building has been around 80 per cent. for some years. In 1932, it was 109 per cent. League campaign work has *created* 10,000 heavy services, 10,000 range circuits, and approximately 350,000 outlets—wiring that would not have gone in without this co-operative promotion system. Now wiring as wiring has not a great deal of utility value, but what has been the load value of it?

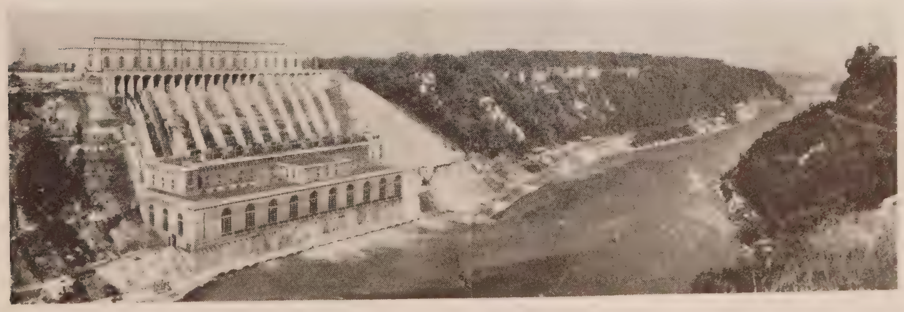
Appliances Follow the Wiring

Here is a table of appliance figures that tell the story:

Appliance	Average for Ontario	Average for Toronto (Non-Red Seal)	Toronto Red Seal House Average
Ranges	26.4	20.7	89%
Refrigerators	7.8	10.4	60
Washers	31.7	68.5	77.2
Ironers	1.	2.8	6
Vacuum Cleaners	24.5	62.8	89
Water-Heaters	10	9.2	76
Grates	5	5.1	37
Percolators	....	20.7	63
Clocks	....	19.2	50.4
Hotplates and Grills	11.7	5.6	20
Irons	91.9	97.2	100
Toasters	48.6	92.8	100
Fans	....	9.7	23

The Red Seal appliance figures have been proven by annual check-ups of each year's Red Seal houses. In terms of money, the average value, at retail, of appliances in the Red Seal home is around $700, contrasted with an average of $270, for the typical non-Red Seal home. A check-up of load from Red Seal houses indicated an increase over Non-Red Seal average houses as high as 300 per cent. The annual increment of load from these 17,500 Red Seal homes, heavily electrified as they are, is a tremendous total, and fully justifies the outlay required to sustain the League. A large membership of manufacturers, jobbers, contractors and dealers along with the Central station has served to make the League a co-operative centre from which emanates a steady promotion pressure on builders, home-owners, merchants, factory executives, and the general public, in the interest of better wiring, more appliances and other equipment, more and better lighting, etc., etc. The total value of *new* business created through League campaigning is estimated at $6,500,000.

While most Ontario cities and towns are not large enough to attempt a duplication of the campaign work of the League, yet the principles involved are applicable in all communities. The methods and plans used can, with suitable modification, be applied in any fair-sized city or town where the utility and the local dealers and contractors will co-operate. Certainly the key to resultful activity in these things is the utility. It is the back-bone of the industry, with a huge permanent investment, with all of the public as customers. It is not merely a power service and supply entity. The other sections of the industry have a right to look to the central station, under present distressing conditions, for vigorous leadership and a broad whole-souled co-operation to improve the lot of the industry. The Ontario Commission needs a larger load, the local commissions need more load, because further declines might force an increase in rates. The Hydro system is built on the basis of public service, and just about the best public service the various Hydro commissions can now give their customers—the great public—is action to replace load losses with new load created by new and energetic methods of promotion.



Making More Use of Our Low Cost Power

By Joseph Showalter, Canadian Westinghouse Company, Limited, Toronto

(Presented to Association of Municipal Electrical Utilities at Toronto, January 24, 1933.)

THE Greeks and Romans of old had much time for meditation, conversation, sport and the pursuit of happiness, as well as their chief hobby; aggressive warfare. In those days, with no labour saving equipment, when mankind was obliged to spend almost all his waking time at hard labour to provide the essentials of existence, this was possible in only one way, the use of slaves.

Every Greek or Roman enjoying so much leisure and luxury had a good assortment of slaves. These slaves performed all the labour of providing food, clothing and other needs and desires, of their lords, and maintaining their homes and estates. All they received was a handful of rice daily and occasionally a new loin cloth. They operated at cost.

We, the citizens of Canada, and particularly of Ontario, are much better off than the Greeks or the Romans. We have far more slaves than they had, and our slaves never sleep and are much more versatile. The Greek or Roman had to clap his hands vigorously and sometimes repeatedly to call his slaves ; we need only exert one finger in pressing a button to call any number of our slaves instantly to our service—and our slaves operate at cost.

As the Greeks and the Romans enjoyed prosperity and luxury because of the abundance of their slave power, we have enjoyed prosperity and luxury because of the abundance of our electric power. Let me quote from an article entitled "Ontario's Unique Electrical Service" which appeared in the Imperial Conference and Industrial Power Number of *Electrical News and Engineering*—:

> "The Hydro-Electric Power Commission of Ontario has now been in existence nearly a quarter of a century, and the anticipations of its founders with respect to industrial development in Ontario that would become possible with the provision of ample supplies of low-cost power have been more than justified. In the last year for which complete data are available—1929—Ontario's agricultural production was $340,000,000; its forests yielded $90,000,000 and its mines $117,000,000. Impressive as are these main items of primary production, the net production of Ontario's manufacturing industries in 1929, that is, the value added to raw materials by industrial processes — greatly surpassed *all* sources of wealth creation in the Province reaching more than $1,000,000,000. The provision of economical power supplies has been a material factor in the attainment by Ontario of the advanced industrial position the Province, with

its population of 3,400,000, now holds."

This statement calls to our attention the fact that, by means of our abundant low cost electric power, we have been able to create in one year, a net wealth of more than One Billion Dollars, an amount nearly double the value of the production of our mines, forests and soil combined. Are not the people of Ontario greatly blessed? They surely are, but are they making full use of their blessing?

According to the last yearly report of the Hydro-Electric Power Commission of Ontario, you gentlemen represent 289 Municipalities, with 447,466 residential electric services, supplying an average monthly consumption per residence of 133 kilowatt-hours, at an average rate of 1.59 cents per kilowatt-hour.

Your 289 municipalities have 75,286 commercial lighting services with an average monthly consumption per service of 344 kilowatt-hours at an average rate of 2.09 cents per kilowatt-hour.

You are supplying electric energy for power to 13,028 industries at various rates, from a fraction of a cent per kilowatt-hour up, varying with the class of power as to amount of demand and time required.

We, in Ontario have very little natural coal or oil, but nature has supplied us with an abundance of water power, much of which has been developed to supply electric power at the lowest cost. Our Ontario people need to be educated to appreciate how highly favoured they are in having so great a quantity of low cost electric power immediately available. We have a marvellous network of transmission lines covering most of the Province, delivering electric energy indiscriminately to the smallest villages and towns and the cities and even much of the rural area, at rates that are remarkably low. Our people should be made fully aware of this, their great birthright, and encouraged to take the fullest advantage of it. As it is all water generated power, the costs are nearly all constant, the more power we use, the less it will cost per unit, the more wealth we will create and keep in Canada and the more will be our enjoyment of life.

You gentlemen who are responsible for the operation of our electrical utilities are very important factors in your various municipalities. You have an opportunity of service greater than the efficient operation of your systems. You are the exponents of the greatest force in our modern civilization, the greatest factor contributing to our prosperity, comfort and happiness, the greatest servant of our citizens, enslaved electricity. It is your opportunity to educate and advise our people in making the fullest use of our low cost power in their homes, public places and industries.

Every factory manager who has taken your advice in the application of electric power or process in his plant is glad he followed your advice and would not go back on it. Every householder whom you have induced to install an electric washing machine, range, refrigerator or other electrical convenience, is happier after having it and would not willingly keep house without it.

The salesman of a large cash register company used a statement

which is most true in regard to electric service and electric appliances in the factory and in the home. This was his statement: "Whatever you need you pay for it whether you use it or not". This is true in the factory, if a motor drive is needed and not used, it is paid for in higher production costs. If an electric heat treatment or other process is needed and not installed it is paid for in higher production costs, wasted material and poorer quality product. It is also true in the home. If an electric washing machine, range, refrigerator, ironer or other electrical convenience is needed and not used, the householder pays for it in labour, fatigue, fuel, wasted food, health, good looks and domestic peace and happiness.

In order to be able to render the fullest advisory service to the industrial users of electrical power, every electric utility manager or his assistants, should become familiar with all the processes and operations in every factory on his system. Few factory men are sufficiently informed on all the available applications of electricity. Their plants can profit by the services and advice of the electrical utility man. The electric utility men all have the matter of motor drive well in hand, and industry is profiting in good power service, high power factor and minimum costs.

It is in the field of electrical heat process that industry can make much more use of our low cost power and profit thereby. However, each case must be carefully studied so that the correct application to the process will be made. An unsuccessful application is disastrous in loss of investment and confidence and in long delayed correct electrical application.

Most industrial electrical heat equipment supplied by responsible manufacturers now, has been developed after much research and experience, and is sure to give entire satisfaction if the right equipment is applied to the operation. The fullest use of the manufacturer's expert's advice should be made before the equipment is purchased. It will be found that when an old fuel heat process has been replaced by an electrical process, the factory manager will be anxious to extend the application as rapidly as his program and finances will permit.

There is a wide range of electrical heat treating equipment, some if it using large amounts of power. In many instances where large ovens or furnaces are used they can be operated at night when the motor load is off, making possible a better load factor, lower demand and a better rate.

There are so many industrial electrical heat applications that I will not attempt to discuss them all. There are many types of ovens with a wide range of temperatures, available for drying enamel, japan, paint and other materials, also for baking foundry cores, and for baking bread and pastry and many other uses. There are space heaters and other forms of heaters to keep material being worked on, at a constant desired temperature.

Electrically heated soft metal melting pots are very clean, efficient and satisfactory, greatly superior to fuel heated melting pots. One field where this class of equipment should be more extensively used is in printing

offices for melting metal in linotype machines.

A small class, but using large quantities of power per unit, is the carbon arc furnace. These are used for melting ferrous metals. This type of furnace is also used in sugar factories to recover barium from the syrup residue after it has served its purpose in causing the sugar to crystallize.

Many types of Box furnaces are available, from the small sizes used by dentists and jewellers to the large sizes for annealing and hardening steel tools and machine parts. The great advantage of all electrical heating equipment is that by means of thermostatic control, the temperature can be automatically maintained within very close limits, ensuring the best workmanship and no burned material.

The field of electric welding is another opportunity to make full use of our low cost power. The use of electric welding has increased rapidly during the last few years. Spot seam and butt welding apparatus is available in a large range of types for all classes of work. In making a survey of your industries you are sure to find many opportunities to advise its use.

Electrical welding is now universally used in the assembly of automobile steel bodies. Hundreds of spot welds are required in each body but the speed and efficiency of electric welding surpasses any other method. The automobile industry has learned to make extensive use of electric welding in the production of car parts.

The large electric apparatus manufacturers make full use of electric welding, from the assembly of the delicate filament, plate and grid parts in radio tubes to the seams of transformer tanks and the fabrication of the largest generator frames.

In parts of the United States where a few builders were able to be independent of prejudiced building restrictions, about one hundred steel buildings have been erected using electric welding instead of riveting. Also some twenty railroad bridges, built entirely of electric welded steel construction, are now carrying railroad trains. Electric welding of steel in buildings and bridges is a proven success. The welded joints are as strong as the steel sections, which is not true of riveted joints, and there is a great saving of steel weight and cost.

Perhaps, some of you gentlemen can overcome the present prejudice in your city architect's departments so as to enable your builders to silence the riveters and save money by making more use of our low cost power in the building field.

Another use for our low cost power, which promises to be profitable, is in electrically heating hot-beds. The Hydro-Electric Commission of Ontario has done some experimenting in this field with very encouraging results. Electric heat applied to hotbeds, instead of manure, results in quicker germination of seeds, more rapid growth and sturdier plants at very small cost per plant for electric energy. The use of electric heat is now in extensive use in commercial hotbeds in Sweden, and might be developed here.

All barber shops should be equipped with electric sterilizers. Recently an epidemic of a contagious face affliction

in one of our cities caused many barbers in that city to install electric sterilizers.

Electric steam generators for industrial processes have brought about an enormous saving in production costs where steam is required for treatment of material. The fuel fired steam boiler was costly to operate and the heat losses in the piping were great. The electric steam generator can be installed right where the steam is required. Any number of units can be put in at any part of the plant. They can be started up quickly at any time and used whenever required. There is no need to keep steam up when not needed, and they occupy little space. Many users report operating costs of less than one-tenth of fuel boiler steam costs.

The variety of industrial and commercial electrical equipment is almost unlimited and the correct use of it will result in lowered costs and the creation of more wealth for our people.

Commercial and public lighting, though well developed here, still provides an opportunity for making more use of our low cost power. In every municipality will be found many business and public places where display lighting, flood lighting and sign lighting is needed. Light was the first service and is now the greatest service enslaved electricity has rendered to its masters. Business flows towards the electric lights.

Our heavily travelled highways need lighting. A few miles of our Provincial highways have been provided, experimentally, with modern electric lighting, but our highway officials have not yet given our highways the protection modern highway lighting provides. Highway lighting is used extensively elsewhere, and though we do not use it here, we pay for it in accidents and loss of lives and property.

We can make more use of our low cost power in our industries, our commercial houses and our public places, but it is in our homes that we can have the greatest service from our low cost electric power. The homes of our municipalities are now consuming an average of 133 kilowatt-hours per month, where they should be using an average of 500 or more kilowatt-hours per month. Our homes need many electrical conveniences and our householders are paying for them whether they use them or not.

Significant evidence that our homes are even now using more electric energy than are the homes in other localities is the fact that while in the United States and elsewhere, seventy-five per cent. of all the house type watthour meters sold are the sizes one kilowatt and smaller; more than seventy-five per cent. of the house type watthour meters purchased by the Ontario Electric Utility Systems you gentlemen represent, are the five kilowatt size. This is the result of the low cost of our electric power.

The first essential necessary to enable the householder to make full use of our low cost power is adequate copper right up to the house distribution panel or load centre. It has been suggested that the entire service line to the house load centre should be the property of the Electric Utility System. At any rate every ordinary home should be served by three number four service wires right through

to the load centre. This will ensure capacity for any household equipment the householder may purchase and the purchase of any equipment will not be delayed because of the unexpected extra cost of a new service installation.

The three conveniences that should really be included in the equipment of every house, along with the plumbing and heating are the electric water heater, the electric range and the electric refrigerator. These three conveniences are essentials to the modern home and as they use more of our low cost power than all the other equipment in the home together, their universal use will result in a tremendous increase in the load on the Electric Utility System and a still lower cost per unit, for power to the householder.

The water heater is the largest user of power in kilowatt-hours and it is probably one of the greatest services rendered to us by our low cost power; giving us a continuous supply of hot water all the year round and doing it more uniformly and at a lower cost than it can be done by means of a coil in the furnace. The extra coal burned to supply hot water through a coil in the furnace costs more than electric current would cost to heat the same amount of water to the same temperature in a modern electric water heating equipment. About 20 per cent. of the coal used in a furnace with coil is required for heating the water.

This subject is being discussed in a separate paper. I will merely give my suggestion as to how it might be handled.

I would recommend the use of a three kilowatt heater with a well lagged tank and a thermostat, either with or without a three heat switch. The thermostat provides diversity. However, it will be found that in any home with the usual family habits, the water heater will rarely be taking current when the range is being used intensively. The three kilowatt heater with a 32 gallon tank will build up a supply of hot water in the night for the heavy morning needs; the morning range load is not heavy. The water heater will operate for about two or three hours and will be off when the range is being used to prepare lunch and many of your systems have their daily peak. Some hot water will be drawn for the noon dish washing. During the afternoon the hot water supply will be built up and the heater will not take current again until in the evening when dinner is over. This service in any of our homes with not more than two bathrooms will require from 200 to 500 kilowatt hours per month, and it, like the range, will all be charged on the lowest rate. Only about ten per cent. of our wired homes at present are equipped with electric water heaters. In the remaining ninety per cent. of our Ontario homes there is a great opportunity to make more use of our low cost power.

The electric range has brought into the home kitchen an atmosphere of cleanliness, convenience, economy and safety that makes this very vital part of the home a pleasure to the housewife and a pride she delights to show to her friends.

About 26 per cent. of our Ontario wired homes are equipped with electric ranges. The other 74 per cent.

certainly should be provided with electric cooking equipment. All must eat and food must be cooked. If electrical cooking is not provided, fuel must be burned, most of which is imported and more expensive, so if electric cooking is not used we pay for it whether we use it or not. Here is an urgent economical need for making more use of our low cost power.

Every Ontario householder, sufficiently responsible to be supplied with electric service, should be provided with electric cooking. No form of fuel cooking is as economical as electric cooking here in our favoured Province. The Electric Utility has a real opportunity for service in establishing some policy whereby electric cooking will be available to all our wired Ontario homes. This would more than double the present use of our low cost power.

The electric refrigerator has come to be recognized as a most desirable, even essential unit of household equipment. Though the first cost is high, it's use more than justifies the investment in the economies affected. Its power demand is small, but it makes good use of our low cost power in total kilowatt-hours used, averaging 50 to 100 kilowatt-hours per month.

We can not hope to make electric refrigeration as universal as electric cooking should become, but every well equipped home with a staple income should not be without an electric refrigerator. About 92 per cent. of the wired homes in Ontario are not yet equipped with electric refrigeration. In this large number there is a great opportunity to make use of many thousands of kilowatt-hours of our low cost power every month.

The three essential units of electrical equipment for the modern home; the electric water heater, the electric range and the electric refrigerator, if fully appreciated and supplied to even half of the homes where they are needed, and being paid for whether used or not, would result in an increase in the use of our low cost power from the present average of 133 kilowatt-hours per month to an average per home of well over 500 kilowatt-hours per month.

As we make more use of our low cost power and raise our standard of living, we not only bring about economies for ourselves, but we make more business for our industries, more employment for our workmen; and more prosperity and happiness for us all.

There are many other home conveniences, familiar to all of you, which enable us to make use of our low cost power. Some should be found in every wired home. All should be found in every completely electrically equipped home.

In addition to the range, water heater and refrigerator, every kitchen should be provided with a ventilating fan, built in if possible. There are also electric motor operated dish washers and food mixers, orange juice extractors and other labour saving equipment.

Every home laundry should be equipped with an electric washing machine, electric ironing machine and electric hand iron, also an electric clothes dryer—a wife saver in bad weather.

There are electric percolators, toasters, egg cookers and other food

treating equipment for the dining room or breakfast room.

For the living room, bedrooms, bathroom and other parts of the home there are still more electrical conveniences available to enable us to make more use of our low cost power. There are health giving sun lamps, air conditioning equipment, electric fans, furnace blowers, heating pads, hair curlers, hair dryers, motor vibrating exercisers, vacuum cleaners, sewing machines, electric heaters, radio sets and clocks and as the country auctioneer says, many other articles, too numerous to mention.

As already mentioned, in order that our householders may use any or all of these electric conveniences, and thereby make more use of our low cost power, all our homes should immediately be serviced right in to the load centre with not less than three number four service wires. Then we can proceed with a campaign of public education, to bring about, among our people a fuller appreciation of their great possession, the equivalent of hundreds of slaves for every home—our abundance of low cost power.

It is education of the public that has raised our standard of living. It is education of the public that has developed a full appreciation of the better things of this life. It is education of the public that has kept the wheels of industry running. It is called advertising or propaganda. Whatever it is called, let's do it.

Just now the average householder's buying ability is low and his credit poor. The credit of your Utility System is the best. The Utility System can arrange the very cheapest financing of electrical equipment to be used in the homes of its patrons. Your Electric Utility Systems would be doing a great service in arranging a policy whereby more of our homes can have the advantage of economical electrical conveniences, without a great immediate strain on their finances. The use of these conveniences, especially water heaters, ranges and refrigerators, will result in an enormous increase in the use of electric energy, increased revenue and a still lower average cost per kilowatt-hour.

Another very helpful policy is one of close co-operation with local dealers and contractors. The prime requisite is to place current using electrical conveniences in the homes. As long as they are approved conveniences it is not so important who supplies them. The Electric Utility should render all help and encouragement possible to dealers selling approved equipment to be used on their system

Some study has been made of the question of renting heavy current using appliances such as water heaters and ranges. With this arrangement the equipment would be installed in the home and a rental charge added to the bill for electric service. Such an arrangement would add considerable load to the Electric Utility System.

In most of our older houses the wiring is entirely insufficient for modern requirements. A campaign of rewiring could be arranged in co-operation with the local wiring contractors. This has been done in some cities, resulting in thousands of dollars worth of business for the contractors and considerable added load to the system.

Electricity is the soul of our

modern civilization. Without it our standard of living would be as it was in the middle of the last century. Electrical engineers and the makers of labour saving, time saving, money saving, health and beauty saving, electrical appliances have made life more interesting and happiness more easy to pursue.

Though electricity has given us leisure, luxury and happiness, our people must be continuously educated in making use of it, and also as to how they can acquire the electrical conveniences for their own service. Public interest must be kept up in electrical progress, and the advantages and desirability of having electricity do our work for us.

Many means can be used to get this interest and education to the public; suitable articles in the news columns of the local papers, paid advertising, demonstrations, talks, leaflets enclosed with electric service bills, public meetings and personal interviews.

All citizens of your municipalities should be brought to realize fully, that they have an abundance of very low cost electric power ready for their immediate use, and that they should make more use of it. It is an economic wrong to cook our food, heat our domestic water and heat process material in our factories by burning fuel bought from other countries with our discounted money, when these things can be done as economically by means of our low cost electric power.

Continuous persistent education of our people in the economy and advantages of our low cost power in our industries, our commercial and public places and our homes will build up your Electric Utility System loads, increase your revenue, keep money in Canada and make our power still lower in cost.

Any people are prosperous in proportion to the use they make of low cost abundant commodities they possess, for their own needs, in their homes, and business houses, and industrialy to create new wealth which can be exchanged for credit elsewhere. *We will be more prosperous if we make more use of our low cost power.*

Let us educate our citizens in MAKING MORE USE OF OUR LOW COST POWER.

Some Notes on Modern Protective Relaying

By E. M. Wood, Assistant Engineer, Electrical Engineering Dept., H.E.P.C. of Ont.

(Presented to Toronto Section, A.I.E.E., November 25, 1932).

(Continued from January Issue)

IV. Zones Containing Transformer Banks.

For the portion of the zone consisting of wiring, external to the bank, on all sides, the requirements for speed and sensitivity are those for any bus zone protection.

The presence of a transformer bank calls for the following additional considerations:

1. The magnetizing current of the transformer representing an input of kv-a. and current without a corresponding output, appears in the relay circuits. Its value is negligible at normal voltages except at the moment of energization and for a few seconds thereafter, when there may be a very high transient magnetizing component. This depends on the value and direction of residual magnetism in the core and on the point of the voltage wave at which the transformer is energized. Fig. 11 upper curve shows the curve on a large bank of transformers. The peaks of current and even the effective value may be very high for a short time, and provision must be made in the relay design to take care of the condition.

It is possible that similar transients exist on recovery of voltage after the clearance of a fault. Such would undoubtedly be the case if the voltage on a transformer had been killed by the fault so that a definite residual magnetism were left in the core, after which the voltage recovered suddenly. Fig. 11 lower film shows the recovery of voltage to normal after clearance of a short circuit which had reduced the primary voltage to about 5 per cent. of normal. This shows no transient. The scales are the same as in the upper curve. While this is the result of only one test and in operation voltage recovers to normal more rapidly in many cases, still according to our observations the recovery transients do not even approach in severity to initial transients. We believe they are usually but not always negligible.

2. *The nature and characteristics of transformer winding faults.*

Faults in a winding usually start as failures turn-to-turn, or section-to-section but may occur from a winding to ground. A turn-to-turn fault causes very high local heating and usually some arcing under the oil, but very little current or voltage disturbance in external circuits. Some measurements made on a large core type transformer on which a short-circuited turn was placed around the core, indicated that at normal voltage the input current to the transformer with a short-circuited primary turn would be about 10 per cent. of normal load current. The current in the turn would be probably 20,000 to 25,000 amperes. This fault would involve more and more of the winding

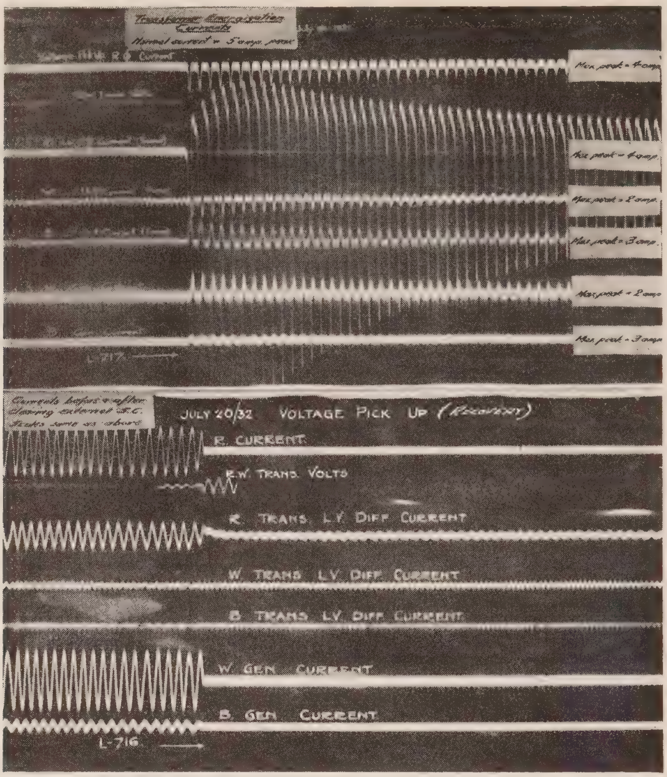


Fig. 11—Oscillograms showing the magnetizing currents of a large transformer bank for two conditions

until sufficient is involved to cause a severe current and voltage disturbance. Failures in large transformers are infrequent, but from observations picked up over a number of years, the writer has the impression that a fault will develop rapidly in units of shell type and quite slowly in the primary winding of a core type transformer. In any case there is much variation in the speed of development of the fault under various circumstances.

In order to repair a transformer, it is necessary to disassemble and restack the core in whole or part. This is the more expensive part of the repair, so that so far as the windings are concerned there is no need for extremely high speeds in clearing. However, undue delay is undesirable for the following reasons.

The arc may damage the major insulation and the second windings, or the excess current may damage by heating, parts of the winding which would otherwise be safe to use again.

Prolonged arcing under oil may disintegrate it into gases which may form an explosive mixture at the top of the transformer. This has been known to be ignited by a tiny spark and to cause a severe explosion.

The speed of clearance should be sufficiently fast that the time of any

internal fault causing a serious disturbance will not conflict with the timing on any line or back-up protections.

Details of the Protection.

Current Transformers—The current transformers at the various sides of the zone should be of such ratio that for currents entering a sound zone the secondary currents sum up to zero (except for the magnetizing component of the transformers).

This requires—

That the current transformer ratio for each voltage rating of the bank should be inversely proportional to the voltage. In other words the product T × t shall be a constant where "T" is the number of turns in a transformer winding and "t" is the number of turns in the respective current transformer secondary winding (per 1 primary turn). Auto-transformers may be used to balance the turn ratio in some cases.

That the secondaries be connected in star or delta if the corresponding transformer winding is connected in delta or star respectively.

Fig. 12 shows this connection for a star-delta bank. Care must be taken as in all zone protections with the characteristics of current transformers, auto-transformers, winding and relays if the desired sensitivity is to be ensured.

Relays for Transformer Zone Protection

The requirements are:—

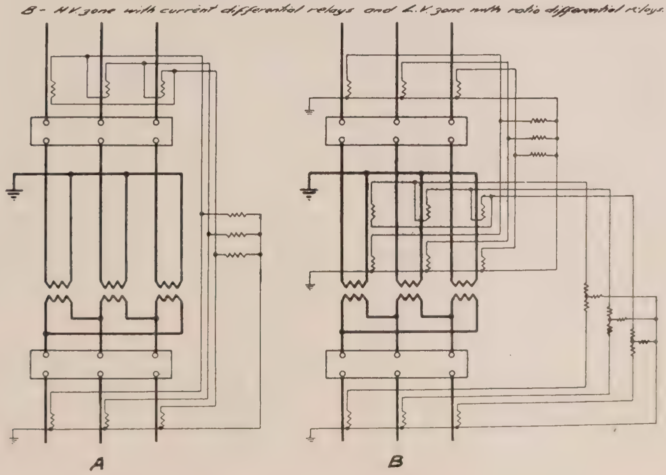
1. That the relay should not trip on magnetizing or recovery transients, and should be stable on heavy through currents to external faults.

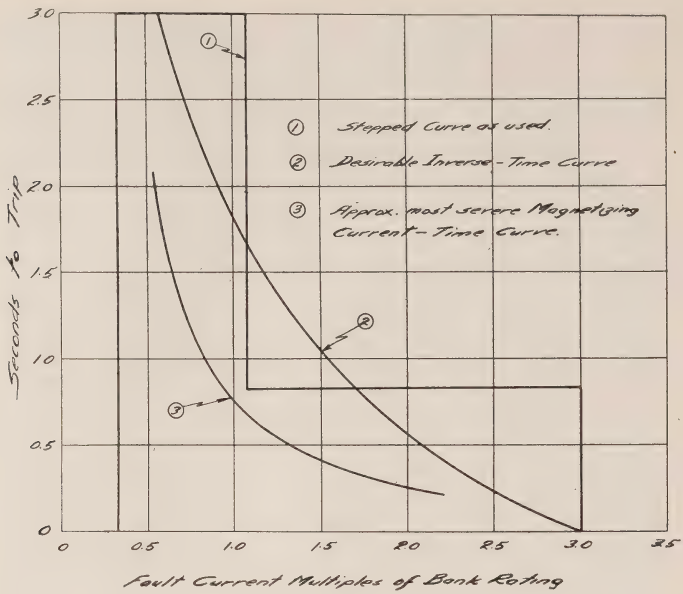
2. That the relay should be as sensitive and high speed as possible in order to limit damage and to avoid conflict with other relay settings. Heavy faults should be cleared with high speed but it is allowable to use a small delay if necessary on minor faults.

Two general methods are in use to take care of the magnetizing transient.

(a) Use of relays with an inverse time characteristic for faults taking low currents with instantaneous

Fig. 12 Star-Delta Transformer Bank Differential Protection.
A - Whole zone, using current differential relays.
B - H.V. zone with current differential relays and L.V. zone with ratio differential relays.





RELAY CHARACTERISTICS FOR TRANSFORMER ZONE PROTECTION (INCLUDING BANK).

Fig. 13

characteristic for faults above the magnetizing transient, that is above 2 or 3 times the bank rating.

An induction relay with suitable time current characteristic and instantaneous attachment for heavy currents meets the requirements. Standard induction relays have not the best possible characteristic for this purpose.

The same results can be obtained from a series of instantaneous current relays with definite timing auxiliaries adjusted to give a composite stepped characteristic the points of which are on an ideal inverse time curve. (See Fig. 13). This has usually consisted of three steps, one current relay being set at 2 or 3 times rating, with instantaneous time; the second set at or just below bank rating and timed one-half to three-quarters second, and the third set low with as long time as necessary to pick up incipient faults. The exact settings depend on the frequency and on system characteristics. A number of installations of this type are in very satisfactory service, both from the point of view of clearance of faults and of stability on external faults.

If the current relays are equipped with operation targets and the time relays with travel indicators, very useful data on transients and the nature of faults can be collected over a period of time from such an installation.

(b) Use of devices for delaying the tripping or for temporarily desensitizing the relay until the magnetizing transient has passed.

These schemes are usually applied to percentage differential high-speed relays. The timing for either scheme is performed by a device of some sort which is actuated by the transformer voltage and starts when the bank is energized. It restores the sensitivity after a definite time required to be sure the transient has passed.

As a bank is liable to be found faulty when picked up it is desirable to provide for instantaneous tripping in case of a heavy fault. This may be accomplished in the case where tripping is delayed by adding an instantaneous current relay with heavy setting. In the case where the relay is desensitized this is only done sufficiently to allow the transient to pass leaving the relay effective for heavy faults.

These relays may be obtained in either the induction or the high speed type. For many installations the induction type is suitable. On 60 cycle systems where the transient is less severe, the natural inertia of the relay will be sufficient to prevent tripping on transients. On high speed type, the precautions outlined above are required.

The relays of either type are usually set to operate on a differential of 20 to 30 per cent. of the load current, and in the high speed type give a very sensitive fast protection. They would be sensitive to recovery transients of relatively low value, because the desensitizing devices do not come into action for a momentary drop of voltage.

(c) Use of a distance (current potential balance) relay. In this relay the differential current is balanced against the correct transformer voltage (Fig. 14). The relay would be set so that with normal voltage it requires a current above the effective value of the transient to cause tripping. In case of an external fault, the voltage may go to zero so that the relay should require a minimum operating current sufficiently high to prevent operation due to errors in the current transformers on heavy through faults. Such a relay applied to a transformer zone will trip at high speed for zone faults external to the transformer. For internal faults the tripping current will depend on the voltage remaining but will lie between 2 to 3 times bank rating for sustained voltage and 20 to 30 per cent. rating for zero voltage. The scheme inherently takes care of magnetizing and recovery transients.

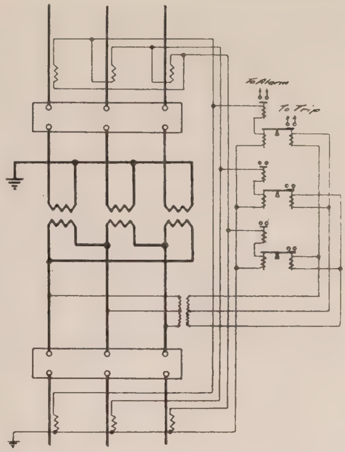


Fig. 14 — Transformer Zone Protection using Impedance Relay.

It is proposed to supplement this by a sensitive differential current relay to give an alarm in case of incipient fault or to clear the zone after several seconds delay required by the possible transients.

It is desirable for simplicity to use one set of relays for the whole zone as shown in Fig. 12a. Occasionally the h.v. or l.v. external wiring or both may require higher speed than can be used on a protection covering the bank. In such case the zone may be covered in sections as shown in Fig. 12b. The relays for the sections not including the bank may be sensitive and instantaneous as in any bus zone protection.

Open Circuit Indication.

A transformer winding or lead will sometimes break, leaving an open circuit, which may transfer the load to other banks without giving any warning. An ammeter in series with either the h.v. or l.v. winding of each transformer will give an indication, which the operator may not see. If an audible alarm is desired, one scheme which will give it is shown in Fig. 15.

* * * *

V. TRANSMISSION LINE PROTECTION.

In any system with a large proportion of overhead transmission lines, the majority of faults will occur in the lines because these are the most exposed parts of the system. Protective relaying for transmission line faults is, therefore, of great importance and from the first has been given special attention.

The majority of faults on high voltage lines begin with the flashover of the insulation at one point, that is as l-g faults, due to lightning or to extraneous objects on the line, or to some similar cause. However, l-l-g faults are quite common due to lightning, and occasionally a simultaneous l-l-l-g fault, due to lightning, will occur. The l-g and l-l-g faults will produce residual currents on a grounded neutral system, the l-l-l-g faults will usually not do so.

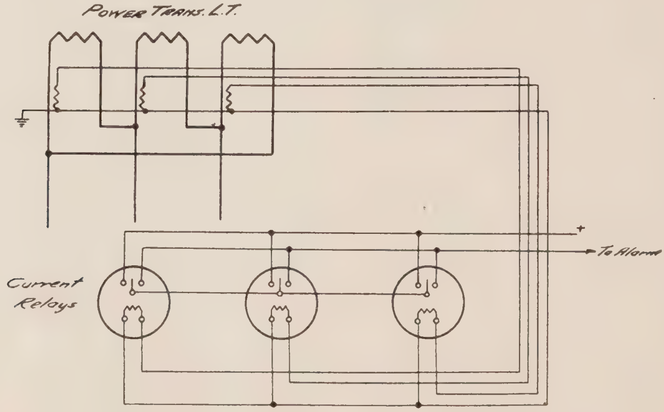


Fig 15. Transformer Open Circuit Indicator.

25% difference between current to open the back contact and close the front. When there is 25% difference between the currents through any two relays the alarm rings.

(by Canadian Westinghouse Co.)

Faults of the 1-1 type will occur in wind or sleet storms, or due to extraneous objects fouling the line. These produce no residual currents.

A system of line relaying, based on the use of grounded neutrals and residual currents, has been developed over a period of years and has given quite satisfactory results as to selectivity and time of clearance for 1-g and usually for 1-1-g faults, and it was felt by many relay engineers that such relaying would adequately take care of line protection because the other types of faults were too rare to require consideration. However, recent experience has shown that on the high voltage lines with horizontal arrangement of conductors, probably as many as 40 per cent. of all line faults involve more than one phase to ground and 1-1-1-g faults are not unknown. This holds also to some extent with lines of any arrangement at 110 kv. or higher. For this reason, relaying methods for the rapid clearance of phase-phase faults have been adopted.

Protection for Phase-phase Faults.

As the terminals of the usual transmission line are far apart, the zone differential scheme so useful in stations is not available in its usual form. The methods in most general use are as follows:

1. Pilot wire protection.
2. Current balance schemes on multiple lines.
3. Distance relaying.
4. Power directional relaying at the line terminals interconnected by a simple pilot for transmitting a control impulse between the terminals.

Pilot Wire Relaying.

This type of protection, which is similar in principle to station zone protection, has been well developed over a number of years. It is applicable only to short lines or, to very important lines on account of expense. We will omit any discussion of the details of this type of protection.

Current-Balance Relaying.

This type of relaying has been used for a number of years and its principles are generally known.

It has been developed in the high speed form for use with high speed breakers.

Wherever suitable parallel lines exist, it is one of the most satisfactory forms of relaying for faults in one line only of the parallel group. Provision must be made to prevent the tripping of the sound line when it picks up the total load after the clearance of the faulty line. A quite recent development for this purpose is to cause the tripping by the current-balance relay to depend on the operation of a fault detector relay of the distance type or on the removal of a voltage restraint due to the fault, so that tripping of the sound line is blocked at the moment of restoration of voltage, after the clearance of the fault.

In order to take care of single line operation, current balance relays must be supplemented by suitable high speed relays for each line. For this reason and because suitable line groups are hard to find and harder to retain, the use of this type of protection is not increasing to any great extent.

Distance Relaying.

This type of relaying has been in use in Canada in the instantaneous

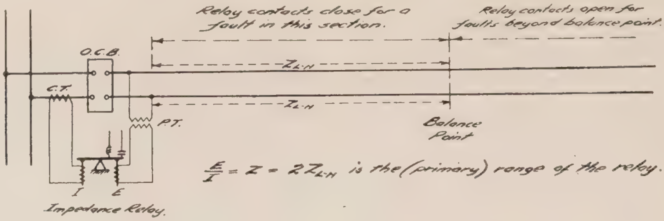


Fig. 16 — Principles of Distance Relaying.

type for about 10 years. Elsewhere, it was taken up and developed in the high speed types when the need for fast phase protection on single line sections became apparent 3 or 4 years ago.

Distance type relays are made in both impedance and reactance types.

In the impedance type, phase-to-phase voltage is mechanically balanced in the relay against the current of the proper phase with the current acting to close the contacts. (See Fig. 16.) For ratio $\frac{E}{I}$ greater than a certain value, which is adjustable and is the distance setting of the relay, the contacts will be kept open, whereas for lower values the contacts will be closed. This ratio represents an impedance which, neglecting resistance of a fault itself, is a constant for any given length of line. That is, an impedance relay can be set to cover any desirable length of line. When equipped with a directional feature, which is required if there is back-feed over the line, and set to cover the line to a point (called the balance point) just short of the remote terminal, the relay will operate for faults in this section and for no others. In that way, it has the characteristics of a zone protection and can be given high speed. On account of minor inaccuracies it cannot, where selectivity with the other stations or lines is required, be permitted to reach the terminal bus. To take care of faults in the extreme end of the line, it is necessary to use a second range which is set to cover the whole line with some margin and which is timed for selectivity with external zones and lines.

In certain cases, a third range set on an overload basis, that is so it will operate at a certain overload in current even with full voltage on the system and timed longer than the second step is useful.

Any relay using a directional element is not better than its directional element. The directional element operates on watts, that is, its torque is proportional to EI cos Θ, where these are the values applied to the relay. On high voltage systems, under nearby conditions, the value of E is very low, and the torque may be very small. For l-l, or l-l-g faults, proper relay connections will provide adequate torque but for l-l-l-g faults, the watts on the relay may be very low. The ordinary induction type relays are very slow and uncertain for 3-phase faults on h.v. lines and are entirely unsuitable for high speed work. Various schemes have been worked out to give high speed at low wattage for the directional element.

Fig. 16 shows the principle of operation of the distance relay in the

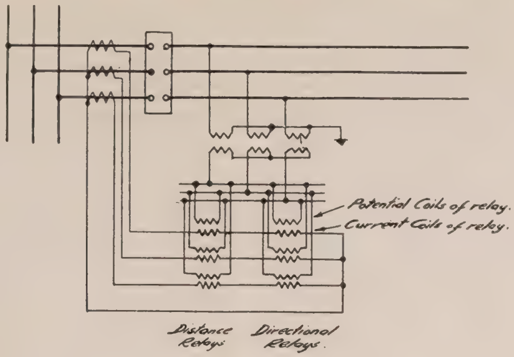


Fig. 17 — Connections of Directional Distance Relays using star connected current transformers.

For L-L faults distance relay measures $2Z_{L-N}$
For L-L-L " " " " $1.73Z_{L-N}$

Range for L-L-L faults is 1.16 times that for L-L faults.
(Z_{L-N} = Impedance of one conductor to neutral.)

simplest application to a single phase line.

Fig. 17 shows the connections for a set of directional distance relays to a three-phase line using star-connected current transformer.

The combination of current and voltages on directional and distance relays to give a high torque on the directional relay for a two-wire fault by using the voltage of a sound phase on that relay is of interest.

Fig. 18 shows the use of delta-connection of current transformers for the distance elements.

It will be noted that with the more usual star-connection of current transformers, the impedance measured by the relay to a point is 1.16 times as great for 1-1 as for 1-1-1 fault, whereas

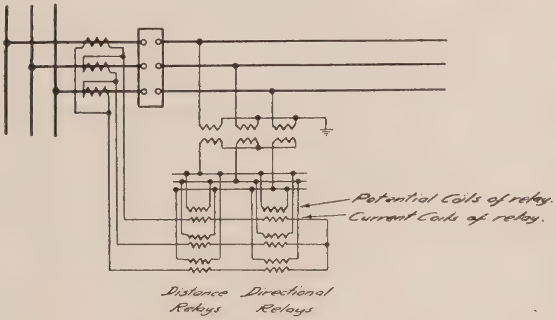


Fig. 18 — Connections of Directional Distance Relays using delta connected current transformers.

For both L-L and L-L-L faults distance relay measures Z_{L-N}

the delta connection of current transformers gives accurate results for both types of faults.

For all types of faults involving more than one phase wire of a line, the impedance distance relay has the following desirable features:—

1. It gives accurate and dependable high speed protection for these faults over 80 to 90 per cent. of the line from the relaying point, which approaches the coverage available, with current-balance relays; and it gives timed protection over the whole line, with a certain back-up effect for terminal h.v. busses. Incidentally, the terminal station zones and tandem line sections must clear sufficiently fast on all heavy faults to be selective with this timing.

2. It is to a very large extent, independent of connected capacity and system conditions both for its accuracy and its speed.

It will operate accurately on any current which will give 4 to 5 per cent. voltage drop over the section protected. It is truly high speed and may be designed to operate in 1/60 second or less for all faults except those close to the boundary conditions of fault current or distance. See Fig. 19 for the time characteristics of a typical impedance relay.

3. It can be used on any line sufficiently long that the fault impedance (arc resistance) does not add a sufficient amount to the line impedance to prevent operation. The arc resistance is proportional roughly to the length and usually about 300 to 500 volts per foot. A high speed relay will cause tripping before an arc starts to expand. From these data, one can easily calculate whether it is safe to try to protect any given short line with instantaneous impedance relays, bearing in mind that the line impedance is usually mostly reactance. As the arc may extend considerably during the timing for the second range, this requires further consideration.

Another aspect is that the line must be long enough to have a drop of 5 per cent. to the balance point for the minimum dependable fault current through the relays.

4. The relay is relatively simple in construction.

Reactance Type Relays.

These relays have been developed to avoid the inaccuracy due to resistance at the fault. They measure

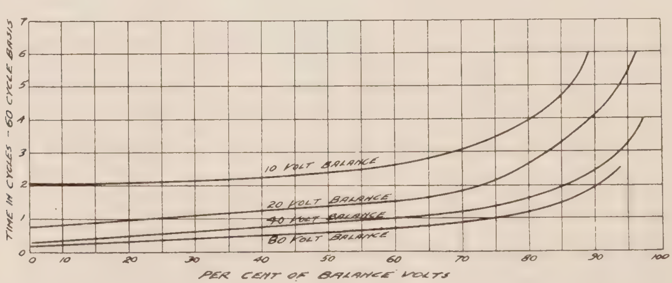


Fig. 19 — Time of Operation of an Impedance Relay.

the reactance to the fault, and their range is not in general affected by the length of the arc except to the extent that any current in the arc from the other end of the line may have a component out of phase with the current in the relay and produce the effect of a reactance drop in the arc which may add to or subtract from the measured reactance of the line, causing an error.

This type of relay can be used successfully on shorter lines than the impedance type on account of the smaller effect of the arc.

All the reactance type relays with which the writer is familiar incorporate the following features:

1. A starting element of the impedance or modified impedance type. This can be high speed. A directional element may be incorporated in the starting element.

2. An ohmmeter, which is energized through the starting element and whose deflection is proportional to the reactance to the fault, that is to $\frac{E}{I} \sin \Theta$

3. The necessary timing device.

The distance relay, of whichever type, has the following disadvantages and limitations:

1. It requires voltage accurately proportional to the line voltage at the relaying point. This calls for either potential transformers or some equivalent potential devices, all of which are expensive on high voltage systems. A saving can be made on the higher voltages by the use of condenser devices with suitable networks.

2. The distance relay, without voltage, will close its contacts at very low current or on the most accurate relays it may balance closed when not energized. Such a relay will trip if it loses its voltage. Since voltage circuits are subject to various sources of interference, some safeguard against tripping on loss of voltage is required. This may take one of the following forms:

(a) A directional element arranged to open its contacts quickly when voltage is removed. In a properly adjusted directional distance relay, the tripping is blocked by the open directional contacts when voltage is removed.

Care is required as to the relative speeds of the directional and distance elements in all cases of removal or replacement of voltage either accidentally or due to the onset and clearance of a fault.

(b) By an overcurrent element provided the system characteristics are such that the fault current is always above load current. The current element acts as a fault detector and its open contacts block the tripping except in the case of a fault.

(c) If the minimum fault current is liable to be below the setting which would be risked on a current relay, the fault detector may be a second distance relay using the same current as the accurate relay and a suitable separate source of voltage. When the installation has more than one range, this fault detector distance relay would be set at the longest range.

The expense for this second

source of potential may become a serious item.

In spite of all these, the distance relay is accurate and suitable for high speed protection of all except the shorter line sections against faults involving more than one phase.

(*Continued in March Issue*)

Association of Municipal Electrical Utilities

Merchandising Committee Report

A meeting of the Merchandising Committee was held in London Public Utilities' Office on Thursday, October 6th, 1932. Those present were:—Messrs. O. H. Scott, (Chairman); D. B. McColl, Walkerville; J. E. B. Phelps, Sarnia; I. Pritchard, Chatham; A. O. Hunt, London; E. V. Buchanan, London; N. Robinson, Stratford; J. J. Heeg, Guelph; W. R. Turner, Hamilton; H. F. Shearer, Welland; A. W. Stewart, Toronto, and G. J. Mickler, and W. C. Dymond, H.E.P.C. of Ontario, Toronto.

The committee considered several matters which were to be reported upon as a result of the previous meeting.

Range Elements and Coils

One of these was the matter of securing a source of supply for range element coils and elements cheaper than what the prevailing prices were at the time.

The secretary submitted a proposal from a manufacturer of coils of this kind with the result that a committee, composed of Mr. Mickler and Mr. Stewart, was appointed to look into the prices of these coils and have tests made as to the quality of the wire and the quality of the elements by the Hydro Laboratory and to report as soon as possible on the findings in connection with elements from several sources.

The prices of the above from independent sources proved to be considerably less than those of standard manufacturers and it was also considered advisable to approach these manufacturers again to see if they could not further reduce their prices for repair parts.

Load Building

The second item of business arising out of the previous meeting was that of reporting on the question of financing consumers' services to facilitate the sale of ranges and other large current consuming appliances.

The results of the investigations made in this connection were presented to the committee with the result that it was proposed that the Papers Committee of the A.M.E.U. be asked to secure for the next convention a paper on "Load Building" with special reference to electric ranges and water heaters.

Metering Device, Instalment Sales

The third item was that of Metering Devices for the sale of electrical appliances.

The secretary reported that while the question of attaching meters to

refrigerators and ranges for instalment payments was quite alive a year ago the scheme had failed in its purpose wherever tried out in Canada since that time, and it was deemed advisable not to go any further into the matter so far as sales by Hydro Shops were concerned for the present at least.

SERVICE CHARGE

The question of the discriminating service charge of 66 cents per month for domestic users having a permanently installed capacity of more than 2,000 watts in appliances was brought up as being a deterent to the sale of electric ranges and other large current consuming devices. Several instances were cited to indicate that sales of ranges and such devices after being practically closed were cancelled when the customer learned of the extra service charge which would be billed as soon as the appliance is installed.

It was recommended that this question be referred to the Rate Committee with a view to having this extra service charge eliminated if possible.

SERVICING APPLIANCES

In view of present conditions it was felt that some activity might be stirred up, not only from a revenue standpoint as far as the Hydro Shop was concerned but also from a current consuming standpoint, by making a survey of the appliances in use in homes of domestic consumers with a view to repairing such of these appliances as are out of order and putting them back into service. Every means of doing this was considered and since the Guelph Light & Heat Comm'n has some such scheme in operation it was suggested that Mr. Heeg prepare for a future convention an outline of the procedure followed in Guelph with all details of tangible results from the scheme.

AIR CONDITIONERS

Literature on a new electrical appliance, the air conditioner, was laid before the meeting and considerable interest was displayed in this particular appliance. It was stated at the meeting that authorities have predicted for the air conditioner a sale among domestic consumers and others to equal or exceed that of electric refrigerators and that the load building properties of this device would exceed that of electric refrigeration. Arrangements have been made for the display of samples of air conditioners at the next convention.

ADVERTISING HYDRO LAMPS

Considerable discussion took place as to the best means for advertising lamps to increase sales.

The secretary laid before the meeting the plans which have matured in connection with the Window Dressing Contest held during the month of October and the Hydro Lamp Guessing Contest held during the months of November and December.

WATER HEATERS

Considerable discussion took place in connection with the development of suitable water heaters for use in the average home and the opinion was advanced that exhaustive tests should be made by the Hydro Laboratory to develop a water heater which proved economical from every angle, one which Hydro Municipalities could recommend to their customers with a

feeling of confidence that it will perform satisfactorily.

In general considerable discussion took place as to the necessity for Hydro Shops to engage in aggressive merchandising to help absorb some of the power supply which is available and it was agreed that every facility should be provided to make aggressive merchandising possible.

Use of Appliances by Hydro Employees

It was drawn to the attention of the meeting that there must be a great number of Hydro employees throughout the Province who are not users of electrical appliances to the fullest possible extent. In order to promote the use of Hydro service it was felt that employees of the Hydro should be among the first to avail themselves of Hydro power wherever possible and while a survey was conducted some years ago to find to what extent Hydro employees were users of Hydro it was felt that such a survey might be interesting if carried on again under present conditions.

(Added during discussion at Convention.)

Cheap Imported Lamps

Mr. H. F. Shearer drew attention to the cheap imported lamps retailed by chain stores and it was agreed to add the following clause to this report.

"THAT we go on record, advising the Sales Department of the Hydro-Electric Power Commission to obtain samples of the imported lamps and make all the necessary tests in order that the data thus obtained may be available to the various utilities for the purpose of combatting the present propaganda behind the cheap imported lamp."

THE BULLETIN

Published by
HYDRO-ELECTRIC POWER COMMISSION
of Ontario

190 University Ave.
Toronto

Subscription Price $2.00
Per Year

Money

By Right Honourable Arthur Meighen, P.C., K.C., Commissioner, Hydro-Electric Power Commission of Ontario

(*Address to Ontario Municipal Electrical Association and Association of Municipal Electrical Utilities at Toronto, January 24, 1933*).

IT sometimes happens that the biographer becomes more famous than the subject of his story. Very often the sponsor is larger than the man he introduces. We never would have heard very much of MacBeth if it had not been for Shakespeare. In this spirit I accept the language of Mr. McCrea and I want to assure him and you that there is little in life which I would really more prize than his own good will.

It isn't my purpose to utilize the privilege you have accorded me to review the work of the Hydro Commission of which I am a humble member, or to devote any time, either, to its defence or to an outline of its policy to come. This is not for the reason that my interest and my heart are not centered there, because of all the work in which, over now a comparatively long public life, I have been engaged, none has so absorbed me and none now commands my first attention quite so fully. I find Hydro a most interesting, indeed, an absorbing occupation and would only like to give vent to this ambition, that I might, as a member of your Board, be of some service in its advancement, in the improvement of its efficiency, and in the usefulness of the institution to this Province.

But as merely one figure in a three day convention, possibly you could bear with me while I speak on another topic, not only for the purpose of diversity, but because to this representative body, gathered from all the corners of our Province, it seems to me that something worthwhile can be done, if only I am capable of doing it, in helping to anchor and steady public opinion in this trying time.

Possibly, before I pass from the Hydro Commission, I could be forgiven if I say a word as to the outstanding experience of the last year.

We have been the subject of a very thorough review at the hands of a

CONTENTS

Vol. XX No. 3
March, 1933

Judicial Commission. I say "we", although I hadn't the honor of being a member at the time the subjects submitted to the Commission were enacted. This seems to make it more my privilege than that of the others to make some comments on the result.

Of the need of the investigation, I have no comment to make at all, and never had. The Hydro Commission never has resisted enquiry and I hope will never be in the spirit or the position where it will. Whether enquiry should be held or not is a matter for others than we. It is our duty to be ever ready—it is our duty so to conduct our affairs that we can survive the penetration of any light which enquiry may bring to bear, and that we can emerge vindicated before those whom it is our duty to serve.

The personnel of the Commission, also, I do not care to comment upon. I do not think either criticism or laudation are appropriate when one is dealing with the work of the Judiciary under British institutions. Suffice it to say that those men are known far and wide as men of competence and impartiality, which words, I believe, apply generally to all members of the Judiciary of this country.

Their verdict is perhaps the most sweeping, undoubtedly the most specific and forceful of any it has ever been my pleasure to read from the hands of a Commission. It is summarized in one sentence at the close and that sentence I will read to you. In this is an epitome of the findings of men who, after prolonged weeks and months of enquiry, and with every possible facility given the critics, at last came to their judgment. The last sentence is this: "We find that in respect of the matters enquired into, the business and dealings of the Commission and the staff have in every respect been conducted on the highest business principles and with great skill and rectitude".

Of the three men entitled to the credit of that verdict, two are before you.—I am not one.

I only say this: On the part of those who demanded this enquiry, who called insistently for months, I think I could say for years, who made grave and startling allegations, who were given not only time and opportunity but were even urged to produce all the evidence they possibly could locate to substantiate their position, for those men now to go forth and complain of the verdict to the people of this province is hardly playing the game.

The Commission does not purpose by any action on its part to bring Hydro into the maelstrom of politics. All we can do is so to conduct our business as to be open to any question, or to any investigation and to be vindicated by the result. We can do no more.

If Hydro is to have a future comparable with its past, you must do the rest. That responsibility is upon you, and you suffer or you prosper by the result.

I want to talk to-day on the subject of money. I feel already that many a heart has dropped and many a spirit drooped since I even mentioned the topic. It is not an inviting subject. It carries harrowing memories, particularly at this time, but we also find in depressions, and this is the longest and the deepest and the blackest, that in our day and generation mankind has been called upon to endure, we always find some loose thinking on the subject of currency and money and all kinds of palliatives and prescriptions, every sort of device and scheme, devised to bring us artificially out of our misery into prosperity again.

I do not think there is anything on which we are less informed, upon which, indeed, it is more difficult to be informed and to do sane thinking, and give sane judgment than on this very question. It is a sort of intellectual quicksand

> " . . . a Serbian bog
> Where armies whole have sunk"

and we prefer to come to something attractive and comprehensible without too great strain of thought, rather than to peer into fundamentals and to the best of our capacity try to understand such a subject as this with which we now perforce must wrestle.

There are three kinds of money or substitutes for money in the world to-day. The basic article is coin. That basic coin is gold, and gold, by its scarcity, by its beauty, by its mobility and by its indestructability is, perhaps, the best of all metals to constitute such a base.

We have about eleven billions of monetary gold in the world, collected over thousands of years. On top of this gold we have an issue of currency. In some countries this is issued only by the government—the bills we carry, or try to carry, in our pockets. In other countries, including Canada, these bills are issued not only by the government but by chartered banks and the provision of the law of this country, as of every country, requires a certain reserve of gold in the treasury against the issue of this currency, a reserve figured on different bases, but ultimately about forty per cent. of currency issued.

This, to those afraid of inflation, just because of the word "inflation", to those, this itself might be deemed dangerous. But experience has shown that such reserve is ample, save in extraordinary contingencies.

We, in Canada, at the time of marketing our tremendous wheat crop in the fall, require a greater volume of currency than on such a gold reserve alone the law will allow us to issue.

Therefore, we provide beyond that a volume of currency every fall, when our large agricultural crop is being marketed. This is a special issue, not on a gold basis, but on bonds of the Dominion of Canada. It is only temporary and is soon recalled.

But there is another form of credit which has just the same utility as coin in the first place and currency in the next, and that is bank credit. This is a sphere in the money subject that seems to be almost wholly left

out of account in the popular view. While currency exceeds basic gold, as a hundred to forty, bank credit exceeds currency, eight, ten or a dozen times.

At a time when in the United States there was currency to a total of $5,802,000,000, namely at the end of 1923, there were deposits in the banks of the United States of $42,163,000,000, or eight times the whole volume of currency. And some of you may enquire, "How could there be that deposit in the banks if there wasn't the money in the country to answer the deposit?"

The explanation is: "There simply was. That's all." There were, say in 1923, credits in their banks of forty-two billion dollars and more, with the total currency issued by the whole nation only $5,802,000,000.

It is the same in Canada. It is the same the world over.

This, to those who fear a word, would look like gross inflation, too, but experience also teaches, that there can be a multiplicity, so long as it is not too big, of bank credit in relation to currency.

Inasmuch as there are, therefore, three forms of money—gold, currency and bank credits—there may also be three forms of inflation.

If one defines inflation as an artificial increase of the volume of money, you could first artificially increase the base. You could add another metal. Such is advocated by many. Such is feared by many and very often there is equal misunderstanding on the part of one side as of the other.

You can also artificially increase currency. You can't add to the volume of gold. There is only so much being produced at the present price, but you can add to the volume of currency. Immediately you add beyond the point at which experience teaches it is unsafe, then there is a rush for gold. People become afraid and the country is forced off the standard and there is then no international medium, except gold, with which it can answer its foreign debts.

There is, therefore, a strict limit beyond which you can not go in the issuing of currency. There is, especially, a stricter limit beyond which any single country can not go. If all nations moved together there would be no object in taking gold from one country to another, but if one country goes alone, then there is disaster in the wake of that country, and disaster at the most vital organ of its whole body politic.

There may, also, be inflation of bank credits. As a matter of fact this is the easiest and the most dangerous sphere in which inflation can take place. This is the place at which inflation took place at a staggering rate during the period which we call "the late boom years". Bank credits rose and rose and rose in the United States. There was an addition in bank credits of fourteen and a half billion between December of 1923 and December of 1928, without a dollar of increase in the currency of that country.

You ask: "How did that take place?" The process is simple. I hope I can make it simple and lucid to you.

Suppose we have three men, "A", "B" and "C". "A" hasn't a dollar. "B" has $20,000 credit in the bank. "C" has $40,000 credit in the bank—

a total credit of $60,000. In the returns of the bank, they would show $60,000 on deposit in respect of those three men.

Suppose that "A" has a thousand shares of United States Steel stock, but no money. That stock is selling, say at $100 a share. "B" takes a notion to buy it. He hasn't the $100,000. He has only $20,000. He borrows the other $80,000 on the security of the stock he is buying and gives a cheque to "A" for the $100,000.

What is the result? The three men had $60,000 on deposit at the first. How much would the bank books show on deposit now? There would be $100,000 to the credit of "A", wouldn't there, and nothing to the credit of "B". "C" would have the same, of course, $40,000. He is not in this transaction at all. There is now a total of $140,000, or an increase of $80,000 in bank credit for these three men, whereas there wasn't a single dollar passed at all. Not a dollar of currency came into the transaction.

Suppose again that United States Steel rises from $100 to $200 and "C" wants to buy the stock from "B". He pays his $40,000 that he had in the bank and he borrows $160,000 more and gives his cheque to "B" for $200,000.

Now, what is the state of affairs? "A" has $100,000 in the bank, and "B" has how much? $200,000? No, he owed $80,000. We will say that he paid it so he will have $120,000 left and "C" has nothing.

The bank credits at this stage are what. Added to "A's" $100,000 is $120,000 of "B's", making a total of $220,000, against the $60,000 which was on deposit in the first place. So bank credit is expanded by $160,000, without currency coming into the matter in any way.

That is exactly the inflation which took place the world over, but chiefly in the United States from 1923 to 1929. That is the inflation, the bubble of which burst at the end of 1929 and brought the world into the distress it is in to-day.

"Now," you say, "if there was inflation between those years, how is it that prices did not rise for farm products and for commodities in general?" The fact is that, though at the end of 1923 there was $5,802,000,000 currency in the whole country, and at the end of 1928, only $5,730,000,000, bank deposits went up in the same period from $42,163,000,000 to $56,766,000,000—fourteen billion and a half with no increase in currency at all. And the reason commodity prices didn't increase was this: commodity production in the country increased at the same time and at the same rate. Great machines developed through the years brought out a volume of production from factories and farms that kept pace with this inflation of bank credit.

But the time came when the banks found themselves over extended. At the end of 1928, if ten per cent. of the depositors in banks of the United States had asked for their money they couldn't have got it. It wasn't there. It wasn't in existence.

The banks felt themselves over extended and they called on John Smith and Brown and all the rest to pay and reduce their credit, and John Smith and Brown had to sell in order

to pay, and as John Smith and Brown and all the rest of the fifty million of people sold, down went prices, and as prices went down there was necessarily more demand for sale until rock bottom was reached.

Such was the product of inflation of bank credits. The end came and the end was disaster.

Now, what I am coming to is this. The volume of money should, so far as it can be controlled, keep pace with the ever increasing volume of commodities produced by the human race. This is tremendously difficult to accomplish because control of the machine is in the hands of not one country but of ninety—predominantly in the hands of five or six great nations and between these there is always rivalry and mutual distrust, and lamentable incapacity to work together as one.

But as a principle it is right and should be attained. Volume of money ought to expand as volume of products grows. If we could accomplish that, there would be a stable level of general commodity values. Prices of this and that would vary according to supply and demand, but the average level would be maintained pretty nearly in equilibrium and if such could be done we could get over these periods of booms and depressions which have been the curse of the world.

I have gone far enough to show you that anything in the nature of mere credit inflation is dangerous because on this continent at least uncontrollable and certain to lead to disaster in years to come. Inflation has to be kept under control and the sphere in which it is least capable of control is the very sphere in which it took place—in the sphere of bank credits.

If we could expand the base and then keep the growth of currency relative to the growth of production and avoid inflation of credits we would maintain a comparatively stable level of commodity values. Such a condition should be the *desideratum* of banks. It is certain that between 1923 and 1928 there was no expansion of currency or of the gold base of currency at all commensurate with the expansion of production. As the mechanism of the world advances, volume of production grows at a far greater pace than it did in earlier times and the reason, in my judgment, that we are in so deep a depression, relative to others in the past is that we failed during later years to keep under control and at the same time make sure of an enlargement of the base of currency and currency dollars preserving them in consonance with this accelerated expansion of commodity volume.

"Now," you ask, "what should be done?" Don't think I am in favor of Canada starting in a race of inflation. Nothing could be madder. You tell me that our money compared to the pound isn't as low as Australia's and Australia is selling wheat at a higher figure in terms of her money than we are. Perhaps, so. But if we take artificial means to devalue our money, all Australia would have to do would be depreciate a little more and then Argentine a little more still and we would have one country racing against the other and rushing like the Scriptural swine right up to and over the precipice.

Let a group of nations add each to

the world's money base or to the value of that base by increasing gold prices —and then issue currency commensurate therewith and the effect would be to improve commodity values and therefore to lower the comparative level of debts and bridge the chasm between debtor and creditor throughout the world. This is vitally essential. Some say this is taking place but it is taking place at such an astonishingly low speed that suffering humanity is going through a trial in the form of unemployment which is terrific.

If, at the coming Economic Conference, the unit of currency of great countries is commensurately reduced in gold content, and the price of gold increased—both are necessary and must be done together—if a value is fixed on which all agree, higher than the $20.67 per ounce, then the gold content of the British pound, the American dollar and the Canadian dollar and French franc would be proportionately reduced.

If this were done, all countries could go back on the gold standard. England could go back and England would redeem her pound in gold, but in less gold than before because gold would be of a higher value.

All this is similar to what France did after the war, but France did it alone by driving the franc down to four cents instead of twenty, and France could not increase gold prices but simply in this way cancelled her internal debts. She claims that she had to do so to save herself from internal bankruptcy.

If leading commercial nations take such a step together there will be a narrowing of the chasm between debtor and creditor. If the value per ounce of gold is raised to $30, Britain could issue five hundred and fifty million of currency and not increase her debt at all. Canada could expand her currency and not increase her debt. The United States could increase her currency by six billion. All would have to act together; otherwise a flight of gold would follow from the country that acted alone and resulting embarrassment to that country would be disturbing and disaster would be probable.

If a number act together and add to the value of gold, it seems to me there would follow a quick relief and a certain relief from the misery in which we wallow now.

There is another thought. In a way we have enough currency in Canada to-day. Our banks are not wanting currency. They have it. Their difficulty, due to psychology, the low price of commodities and the fact that people can't make money, is in getting currency out in safe loans. The task of getting currency among people after new issues take place is not an easy task either. It could be done by retirement of certain of our obligations, and secondly by the inauguration of a modest program of public works.

If, in that way, we could get currency commencing to trickle again, that stream would expand, volume would grow and the journey back would be more rapid than those slow processes we are compelled to adopt to-day.

I have sought to outline what are, undoubtedly, basic principles of money, and I have sought to indicate what, in the judgment of one who

surely cannot pretend to be an expert, ought to be a way to improve this world situation.

I want to warn against what is undoubtedly, manifestly fatal. That is individual inflation by the individual country.

There are even those who advocate an attempt to reverse the whole wheel and steering gear of progress by abandoning the benefits of machine production. We hear, and it is no more foolish than many other things we hear, that if we could only get rid of machines and go back to where a little job would take twenty men, where it only takes one with the machine, we would be distributing employment.

I believe in distribution of employment, but it has to come by shorter working hours and days. It never can come by reversing the chariot of progress and returning to day labor.

Have we any idea what machinery has done for the world? It has changed the whole task of making a living from hard, heavy grinding toil into the practice of alertness, dexterity and skill. It has rebuilt slums of cities in every quarter of the globe; it has moderated the rigors of climate; and of nature; it has multiplied the interests and diversities of life; it has spread wider and wider still the circles of culture and comfort; it has carried not a few, but vast proportion of mankind in joyous travel over the oceans and continents of this earth; and it has brought luxuries, and entertainments of the rich, into millions of humble homes. Don't let us trifle with the magic of a giant such as that!

My last word is this: Let us plant our feet on the solid rock of the teachings of experience; let us cling tenaciously to principles which have proven sound and right and let us make certain that not passion or despair, but real intelligence governs everything we do.

Electric Water Heater Campaign

DURING the January convention of Ontario Municipal Electrical Association and the Association of Municipal Electrical Utilities, an announcement was made of a proposal of the Hydro-Electric Power Commission of Ontario to install flat rate electric water heaters as a means of increasing the sale of surplus power. This announcement was based on investigation, study and experimentation by the Commission's engineering staff then in hand.

Towards the end of February sufficient advance was made to permit official announcement to the Municipalities of a plan for a six months' campaign for the installation of such heaters. Following this the Commission has prepared a pamphlet describing the proposed water heating installations, from which the following general information is extracted.

* * * *

General Description

This pamphlet contains a description and details of installation of equipment which the Commission proposes to supply in connection with a "Six months' Campaign" for the installation of Electric Water Heaters as a means of increasing the sale of surplus power.

The plan provides for the installation of "Flat Rate Water Heaters" only where these constitute a *new load*. It is not intended to replace Flat Rate Water Heaters already installed.

Electric Water Heaters will be installed, where satisfactory tanks are supplied and maintained by the Customer in a suitable location. *Flat-Rate Heaters* will be installed close to the bottom of the tanks and *will operate continuously.* They are equipped with thermostats set to trip off the circuit just below boiling temperature, and are intended primarily as a safety device. These Flat-Rate Heaters will be supplied and installed complete with thermostats, tank covers, insulation and wiring, all of which will be paid for by the Hydro-Electric Power Commission of Ontario and will be free of any cost whatever to the Consumer or to the local Hydro-Electric Systems, the consumers paying only for the current used at approved rates.

It may be advisable in some cases to install a booster heater to provide quick recovery of hot water in the top of the tank. The cost of the booster heater and the installation of same will be financed by the Hydro-Electric Power Commission of Ontario, and a nominal monthly charge will be made which will be sufficient to pay for the heater over a five-year period, with a view to the ownership of this equipment being transferred to the User at the end of the five-year period.

Booster heaters will be installed in the upper hole on the side of the tank or about ten inches from the top of the tank. The capacity of these heaters will vary with the requirements of the various Users.

Booster heaters will be equipped with thermostats which, when installed, will be adjusted to operate between the temperature limits of 125 to 135 degrees Fahrenheit.

Customer Data

When a Customer indicates his desire to install an electric flat-rate water heater, a preliminary survey will be made by the local Hydro System of the Customer's premises to determine the conditions of the wiring in the house, the present system of hot water supply, and the requirements of the User as far as hot water supply is concerned. For this purpose a special preliminary survey card is provided, and when the System representative visits the premises, he will fill out on this card the information required. *From these data someone capable of interpreting the same will decide the type and capacity of the flat-rate water heater to be installed;* and, also, whether it is advisable for the Consumer to install a Booster heater and the type and capacity of same, in order that the Consumer may obtain by the use of these heaters a satisfactory hot water service.

Selection of Heater Sizes

As a guide in connection with the radiation from tanks, it can be assumed for a 30-gallon tank insulated with 2 in. of rock wool that the radiation losses will be from 1.1 to 1.25 watts per degree fahrenheit rise, or the watts radiation losses from the tank insulated in this way will be 100 to 125 watts for water at about 160 to 170 degrees fahrenheit. Adding to this the radiation losses from piping, etc., the total radiation losses could be assumed on the average from a 30-gallon tank installation to be 200 watts with the water temperature at about 170 degrees.

The following is intended to be a guide to those interested in the installation of electric hot water heaters in connection with deciding the size of heater required—

Number of persons in Family	Flat Rate	Booster
Up to 3	400 watts to 500 watts	1500 watts
Up to 4	500 watts to 600 watts	1500 watts
5 to 6	600 watts to 750 watts	1500 watts

A family of 5 or 6 should have a 40 or 50-gallon tank, preferably the larger.

Where larger boosters are required for tanks of 50 gallons or over, the cold water pipe may be brought in at the bottom of the tank, and the cold water opening at the top used to insert an additional heating unit, i.e., there would be two booster heating units both controlled from the large capacity thermostat.

Large Families and Large Tanks

Size of Tank	Flat Rate	Booster
50 gallon	750 watts to 1000 watts	1500 watts to 3000 watts
60 gallon	1000 watts to 1250 watts	1500 watts to 3000 watts
80 gallon	1500 watts	3000 watts
100 gallon	1500 watts to 2000 watts	5000 watts

In deciding the size of heaters required, due regard must be taken of the method of heating hot water to which the consumer has been accustomed. If he has been accustomed to turning on a gas heater only on wash days and bath days, he has been trying to keep his cost of water heating to the lowest possible figure and, therefore, a reasonably small flat-rate heater should be recommended. If the customer had an automatic gas heater, or a large coal jacket heater giving him an abundant quantity of hot water, it will then be advisable to recommend a larger flat-rate installation, and in some cases also a fairly high capacity booster.

Customer Contracts

When the User's requirements have been established, and the type and size of heater, or heaters, have been determined, a formal contract, or contracts, will be signed by the User on the special card forms provided for this purpose. Separate contracts will be signed for flat-rate and booster heaters; these contracts being signed in duplicate, one copy for the Municipality's use and one for the User.

Customer's Obligations

The Customer must supply and maintain a satisfactory tank properly located.

Where the tanks are so located, i.e., in a corner or close to a wall or object, so the cover and equipment cannot be installed, the Customer must, at his own expense, re-locate the tank in a satisfactory location.

If the wiring has to be carried up through partitions at considerably above the average cost, the Customer may be required to take care of such extra expense.

Standard water tanks are installed with the cold water down pipe connected at the cold water inlet at the top of the tank in such a way as to conduct the cold water to the bottom of the tank through a pipe inserted in the tank. In some instances installations have been found with this cold water down pipe left out by the Plumber. This pipe must be inserted in such cases, otherwise the installation will not be satisfactory.

Where ½ in. piping is used and there is a horizontal run of from 3 to 4 ft. in the hot water pipe immediately adjacent to the tank, no special trap is required as the horizontal pipe is itself a sufficient trap to prevent circulation of hot water up to the various kitchen and bathroom taps.

If there is less than about 3 ft. of horizontal run in the hot water pipe immediately adjacent to the tank, a special trap in the form of a ball check valve should be installed. Where larger pipes than ½ in. are used, check valves should be installed where the horizontal run is less than six feet.

In order to obtain the most efficient use of an electric water heater, and, especially, a "Flate Rate heater", it is necessary that all leaky taps be repaired and maintained in a satisfactory operating condition on account of the fact that a small leak running continuously may seriously reduce the amount of hot water which may be supplied from a tank. It must be realized at all times that with the use of flat rate heaters, the heat storage principle is involved and a leaky tap will make a constant drain on this storage, thus reducing the

amount of hot water available, and lowering its temperature.

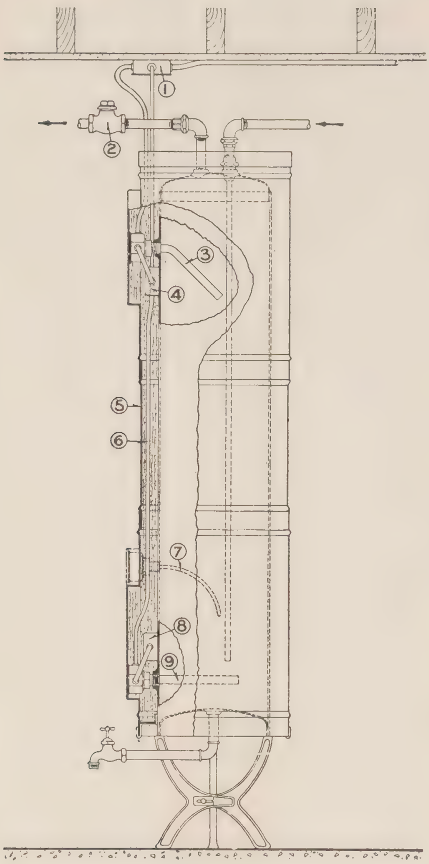


Diagram of immersion type electric water heater installation:—

1. *Junction box.*
2. *Check valve in hot water line.*
3. *Booster Heater, tubular swivel type.*
4. *Thermostat for booster heater.*
5. *Sheet metal case containing rock wool.*
6. *Special lead sheathed cable used to wire heaters.*
7. *Flat Rate Heater, hairpin type, bent (alternative to 9.).*
8. *Thermostat for flat rate heater.*
9. *Flat Rate Heater, tubular immersion type.*

TYPE AND APPLICATION OF ELECTRIC HEATERS

The heaters to be used are of the following types,—

(a) The Hairpin
(b) The Tubular Immersion
(c) The Tubular Swivel
(d) The Strap-on

The *Hairpin Type* may be used in either location: i.e., at the top of the tank for booster purposes, or at the bottom of the tank for flat-rate use, and where the hole in the bottom of the tank is more than six inches from the bottom, it will be necessary to bend the element of the heater in a long sweeping curve in order to have the tip of same extend below the hole in the side of the tank to a distance of not more than five inches, thus enabling a greater use of the storage capacity of the tank. This bending is also necessary in some cases to avoid the incoming cold water supply pipe which is usually installed directly in line with the holes provided in the side of the tank.

The *Straight Tubular Type* heater may only be used for flat rate purposes, when the hole is not more than six inches or so from the bottom of the tank, and for booster installations where there is no incoming cold water supply pipe to interfere with its installation, also, where holes are at least twelve to eighteen inches from the top of the tank.

The *Tubular Swivel Type*, however, is adaptable to use for either booster or flat rate purposes for any location of the standard holes provided in the tank. The heater may be adjusted to miss all obstructions which may

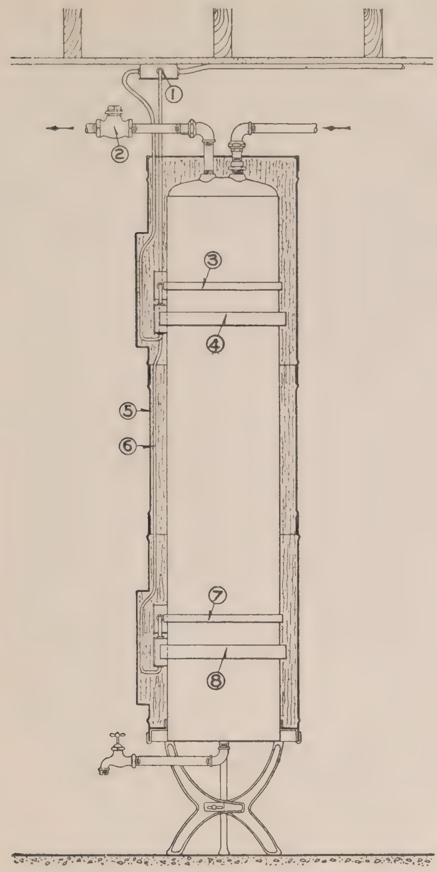


Diagram of Strap-on electric water heater installation:—

1. *Junction box.*
2. *Check valve in hot water line.*
3. *Thermostat for booster heater showing strap.*
4. *Booster Heater, strap-on type.*
5. *Sheet metal case containing rock wool.*
6. *Special lead sheathed cable used to wire heaters.*
7. *Thermostat for flat rate heater, showing strap.*
8. *Flat Rate Heater, strap-on type.*

be installed in the tank and also makes it possible to point the heater downward in order to obtain a greater storage from the existing tank.

The use of *Strap-On Type* heaters is recommended in all cases where the character of the water supply is such as to result in the formation of excessive scale on heater elements of the immersion type. These heaters when used as flat-rate heaters are recommended to be installed at a distance of approximately six inches from the bottom of the tank: i.e., the centre line of the heater should be six inches above the lower line of rivets. The top heater should be so located that its centre line is approximately ten inches from the upper line of rivets. Further, the strap-on type of heater lends itself to any application and may be used where the holes in the tank are so located as to make the installation of immersion type heaters impracticable.

* * * *

The heaters, thermostat and other electrical devices and equipment to be used are standard products developed by various manufacturers. The tanks are such as are ordinarily used for domestic hot water service. The heat insulation for the tank is however a development of the Commission and is of comparatively simple construction and application. The tank covering consists of a sheet metal case placed over the tank leaving a space of from two to three inches which is packed with rock wool, the heat insulating material used.

All materials used in the installation of these heaters will be purchased from the various manufacturers and the installations will be made by local

labor contracted in the municipalities wherever possible.

The public is showing considerable interest in the plan and the municipalities are entering into the scheme whole heartedly. A number of municipalities have already signed agreements to proceed with installations.

Some Notes on Modern Protective Relaying

By E. M. Wood, Assistant Engineer, Electrical Engineering Dept., H.E.P.C. of Ont.

(Presented to Toronto Section, A.I.E.E., November 25, 1932).

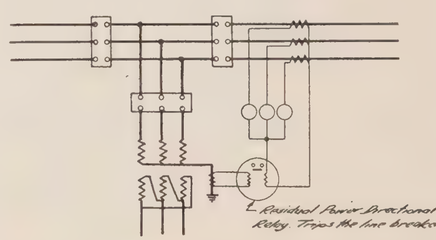
(Continued from February Issue)

VI. Protection of Lines for Ground Faults.

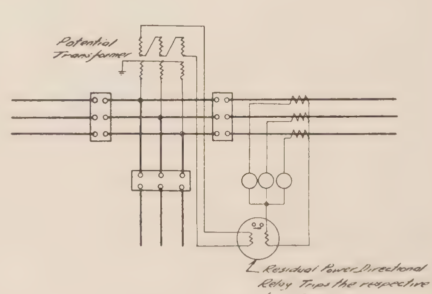
On a system with grounded neutrals any current which leaves a line conductor and returns to the neutrals via ground as in a fault to ground, is a residual current and can be measured in the neutral (common) lead of the star-connected secondaries of a set of current transformers in the three phases of that line. This current, generally speaking, represents a purely fault current, quite independent of load. It can, therefore, be used in a current relay of sensitive setting which can be made selective by graded timing as in overload relays.

A relay carrying the residual current of a line can be made directional in the manner shown in Fig. 20. The residual currents may be assumed to flow from all grounded neutrals of transformer banks through the three phases of the respective transformers and the branches of the line system to the fault. The distribution of the residual current will be governed by the zero sequence impedances of the respective branches of the network. This is shown for a simple system in Fig. 21. Each transformer neutral, therefore, provides a reference current of constant direction no matter where the fault is located. A wattmeter relay in which this current is combined with the residual current of a line as shown in Fig. 20a will be very

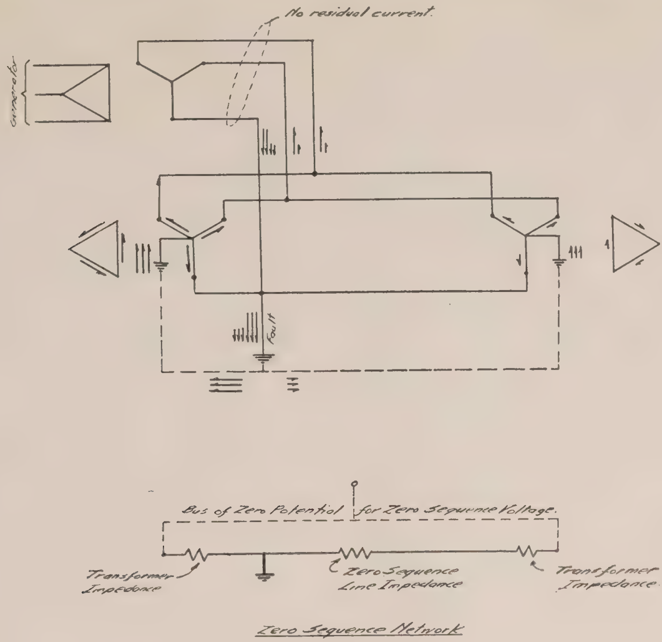
Fig. 20—Residual Power Directional Relays.



(a) Current-Current Type



(b) Voltage-Current Type.



RESIDUAL CURRENT DISTRIBUTION

Fig. 21

reliably directioned, and will have a torque proportional to $I_{res.} \times I_{neut.} \times$ cosine of the angle between these currents. As a large proportion of the residual current at a point adjacent to a transformer bank with grounded neutral will be supplied through that neutral, the two currents will be in phase and the torque proportional to $I_r \times I_n$.

If there is no transformer bank with grounded neutral at the relaying point, the residual voltage may be used in place of neutral current in the directional relay, as shown in Fig. 20b.

On a dead grounded neutral system, the residual current is nearly 90° out of phase with the residual voltage for overhead lines because reactance greatly predominates over resistance in the zero sequence network. A wattmeter reading $E \cdot I_r$ cos 90 has little or no torque. The torque can be greatly increased by any scheme which will give the relay maximum torque when the phase angle between I and E is not zero. The phase angle for maximum torque is usually adjusted for about 45°. Such a relay has quite definite directional characteristics.

If the neutral is grounded through a resistance so the angle $E_{res.}$ to $I_{res.}$ is small, the relay whether current/current or voltage/current with true wattmeter characteristics is an ade-

quate directional feature for ground fault currents.

Reliable directional action can be obtained in this way on any grounded neutral system for ground faults. If the directional relay is to be used with other relays, it may well be of the high-speed type and should be sensitive.

This residual power directional type of relay either in the current/current or voltage/current form when using the induction disc principle with an inverse watt-time characteristic and with time adjustment controllable by the spacing of contacts, has another useful characteristic.

Examination of system grounded dead or through very low impedance will reveal the following characteristics. See Fig. 21,—

The nearer the fault is to the relaying point when this is near a grounded neutral, the greater is the line residual current and the greater the current in the transformer neutral.

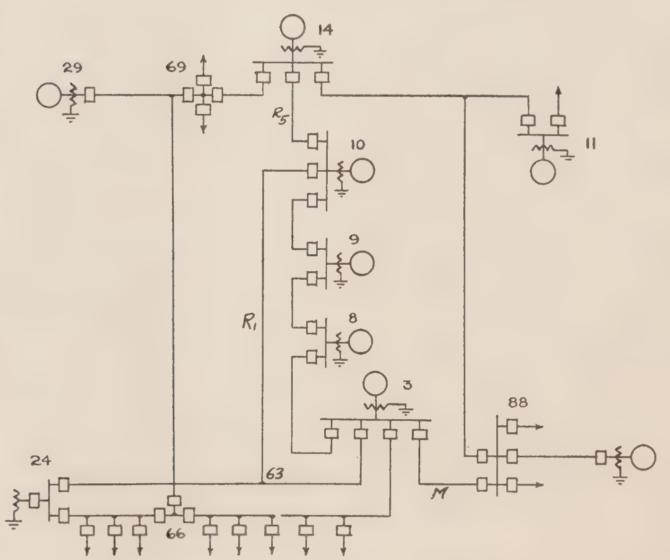
The nearer the fault is to a voltage/current relaying point, the higher the residual voltage.

The watts on the relay will be very high if the fault is nearby but will fall off rapidly as the fault location recedes from the relaying location. The result is that in a network with many points grounded, the torque on such relays on the defective line will be high and give quick clearance, whereas on the sound lines, the relays are either very positively blocked by direction or have so little torque that they will be slow enough to be selective.

For example on the 60 cycle, 44 kv. system shown as Fig. 22, some of the relative torques on this type of relay

Fig. 22

44 KV. MULTIPLE GROUNDED SYSTEM



for normal-connected generating capacity are as follows,—

On Line R1 for a fault near Station 10

The torque on the relay at Station 10 is 900 units.

The torque on the relay at Station 3 is 8.5 units.

One Line R1 the torque on the relay at Station 10

For a fault near			10	is	900	units.
"	"	"	3	"	4.6	"
"	"	"	24	"	0.165	"

Relays on Line M at Station 88

For a fault at			88	is	100	units.
"	"	"	3	"	7.5	"
"	"	"	63	"	1.8	"

Relays on Line R5 at Station 10

For a fault at			10	is	204	units.
"	"	"	14	"	55	"

These indicate in a general way how, in a system of this description, such relays will give very successful protection against ground faults with very little, if any, resort to time settings.

The current/current type is simpler and more positive where it can be used, but the voltage/current type can be used successfully either alone or in combination with the current/current types after a careful study of the system. For the proper application of either type, a careful study of the residual currents and voltage at the relaying points for various fault locations is very desirable.

Neither type is of any use on a system grounded through a high resistance or reactance. The value of residual current is controlled in this case by the neutral conditions and the location of the fault makes little difference to the value of neutral or residual current or of torque on the relays. Either type, however, is useful on such a system as a directional element for other types of relaying.

Even on dead grounded neutral systems the power directional residual relay has certain limitations.

1. Having an inverse time characteristic, the relay time will depend to some extent on the system capacity connected and on the number and arrangement of the banks with grounded neutrals.
2. The relay is subjected to a tremendous range of torque for various locations of faults. For distant faults, it will be slower than is desirable. In fact it is not a high-speed scheme except for very heavy faults.
3. It may not be selective without time setting, and it probably is not possible to adjust the time settings for selectivity under all desirable system arrangements.

In brief, it falls short of the precision, dependability and speed of the distance type protection as applied for phase-to-phase faults. In spite of this, it has a wide field for successful application. On 60 cycle systems with grounded neutrals, a combination of distance relays for phase-faults and directional residual relays of this type for ground faults comes close to being standard practice. On 25 cycle systems of high voltage where bushing current transformers must be used, a difficulty is experienced which is common to all 25 cycle residual relay applications, namely, that the induction relay has often too high impedance to allow the desirable sensitivity to be obtained.

In systems where the directional residual induction relay is not considered fast enough or is otherwise unsuitable, various other schemes are available.

(a) Current balance protection may be applied to suitable lines using residual currents in the same way that phase currents are used, but with more sensitive settings and without provision for effect of load currents.

(b) The induction type residual power directional relay may be supplemented by a combination high-speed directional and current relay with the current relay set sufficiently high that no external fault will cause it to operate.

(c) Distance relays may be used in place of the current relay for high-speed protection for phase-ground faults. One relay is required for each range per phase using l-g voltage and phase current or residual current.

Whereas the distance relay may be applied with precision to phase-phase faults, its application to l-g faults is beset with pitfalls. Some of these are,—

1. The fault impedance (resistance) includes not only that of the arc but of the tower or pole ground and of the return path. These latter may vary greatly with different locations on the line and may have high values—higher than the impedance of the line. This difficulty may be overcome to some extent on a steel tower line by interconnecting the towers with one or more skylines which gives the effect of a number of tower grounds in parallel.

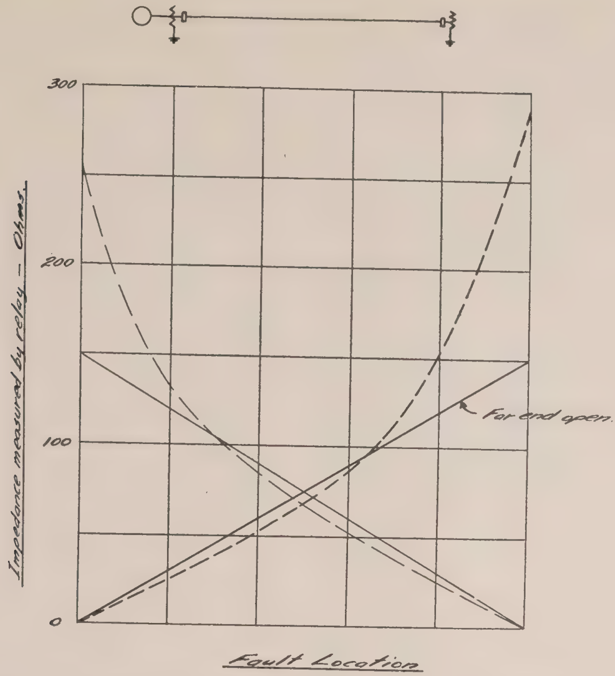
2. The reactance of the line for ground faults is not the normal l-n reactance as taken from the tables but is based on the "zero sequence reactance" of the line which depends on the distance of the effective return path—the "equivalent ground plane." This varies with details of sky wires, soil and probably other factors. It is difficult to calculate but may be determined by measurement between any two points.

The chief requirement is that the impedance of the line shall be higher from the relaying point to the balance point than to any intermediate point and lower than that to any point beyond.

3. The apparent impedance of a line section as measured by such a relay depends not only on the zero sequence impedance of the line section but on the effect of currents in adjacent conductors of the same line and of residual currents in adjacent lines. In general, the ratio $\frac{E_{1\text{-}g}}{I_{res.}}$ or $\frac{E_{1\text{-}g}}{I_1}$ measured by the relay does not necessarily bear any fixed relation to the length of the line or to the location of the fault. The relation changes with the fault location and with the system arrangement.

It is apparent that careful investigation is required for every application and setting of such a relay. Discussion of the methods of study involve the use of the method of symmetrical components. They are well covered in a paper on "The Basis of Distance Relaying"[3] in which

[3] By Lewis and Tippett, A. I. E. E. February, 1930.



Note I : Relays use residual current and line-to-ground voltage.
Note II : In this case both ends may have a setting of 150 ohms without risk of reaching faults beyond the far breaker.

CHARACTERISTIC CURVES OF GROUND DISTANCE RELAYS

Fig. 23

various somewhat complicated methods are proposed for counteracting the sources of error so that impedance relays can be used accurately with phase current and l-g voltage for l-g faults.

However, there are numerous places where stepped range directional distance relaying of this type, without the complications proposed can be used successfully for l-g faults, and in fact is the best scheme available. For example, if a line section has a dead-grounded neutral at each end, a residual distance relay must be given a very long setting to reach the far end, and may safely be set beyond the open line ground impedance. (See Fig. 23.) However, the relays at the two ends will always overlap the centre of the line. The result is that for an l-g fault one end trips out instantly followed at high speed by the second end, both on the instantaneous range. This gives faster clearance than almost any other type, and has the advantage that it is less affected by the connected generator capacity than any high-speed residual current type.

Modified Pilot Schemes Using Control Circuits.

Protection of lines by distance relays for phase faults and residual directional or distance principles for

ground faults is being applied widely and successfully on large systems and constitutes an important advance in the art of line protection.

Aside from the fact that it is expensive on account of the necessity for accurate potential devices, it has two important deficiencies.

1. For certain faults, as on the end section of a line remote from the relaying point, the clearance is delayed. This may not be serious on long lines with high impedance, so that the system voltage will recover after the end nearest the fault clears, but is serious in some cases on the shorter lines.

2. Distance relaying cannot be applied to short lines. There are many cases of lines of 5 to 20 miles in length for which the ordinary zone type pilot protection is costly and impracticable and which are too short for the best application of distance relaying. The relaying on these should be fast and accurate. Some method of relaying to give results equivalent to the pilot wire scheme but applicable to longer lines is very much needed.

For a number of years various engineers have been attracted by the idea of using power-directional relays at the ends of a line, and interconnecting them by some sort of control circuit so that the combination will indicate whether the fault is inside the line section protected, or external to it, and will trip the terminal circuit breakers if the fault is internal. Such a scheme would have approximately the characteristics of a zone protection.

Anyone following the current literature on the subject would note the increasing number and variety of such schemes which are being used.

The essential features are:—

1. *At each terminus* there must be fault detector and directional relays for phase and ground faults.

By fault detector relays, we mean those which are not affected by ordinary load currents. They may be current relays set above load currents or they may be of the impedance distance type.

2. *Between the ends*, one or more channels for conveying a control impulse; for example, a d.c. trip voltage.

Each channel may consist of a telephone or supervisory pair or it may be a high frequency carrier current. On the British 132 kv. Grid where this type of relaying has been quite largely adopted for short lines the usual channel is a telephone pair, leased from the General Post Office and used normally for telephone purposes. The important thing is that the channel should be reliable and capable of carrying at high speed a control impulse to operate the necessary auxiliary relays.

Most of the schemes which we have seen to date fall into one of the following categories.

1. *Series Trip Method.*

The directional relays are arranged to close their contacts for power flowing toward the line section which is to be protected. The breaker trip coils and the two sets of contacts are connected in series, so that both breakers are tripped if both relays close their contacts indicating a fault in the section.

Fig 24a shows this in bare outline.

Certain additional auxiliary tripping relays would be required.

This scheme is simple and tripping is completely instantaneous and selective. It has the limitation that there must be fault current infeeding from both ends—which may not be the case unless there are always generators on both ends of the line.

In this scheme, if the relays keep their contacts closed on load current the onset of an external l-l-g fault may cause the relay of one phase to close at one end and allow the contacts on the other phase or phases to remain closed due to load at the opposite end, resulting in wrong tripping. The remedy for this is either—

A separate pilot channel for each phase.

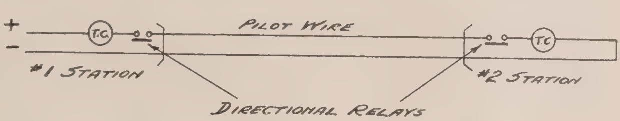
Use of polyphase directional relays with a separate ground direction relay where necessary.

Use of fault detector relays with the directional elements phase by phase so that the circuit is not closed through except under fault conditions.

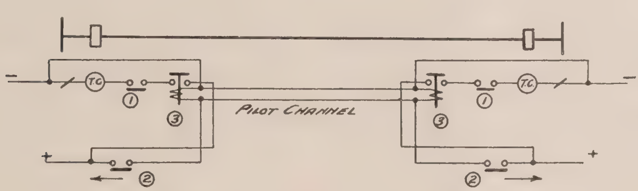
2. *Transfer Trip Scheme.*

If ordinary single range directional distance protection is applied to both ends of a line for phase and for ground faults, the relays at one end or other of the line (usually at both ends) will trip the local breaker for every fault, that is, the ranges will overlap at the

(a) Series Trip Scheme



(b) Transfer Lock-out Scheme



① Fault detector (tripping) relays, either current or distance type as required.

② Power directional relays to close contacts for a fault in the direction shown by the arrow—for lock-out.

③ Circuit opening (lock-out) auxiliary relay.

The lock-out relays must be more sensitive and faster than the fault detector.

Additional provision is required for terminal station faults.

Fig. 24 Pilot-Wire Schemes.

centre of the line. If the pilot channel is used to carry the trip impulse to the other end of the line and trip the remote breaker, instantaneous clearance will be obtained for every fault. The line must be long enough that relays can be set definitely short of the end of the line section. It is also necessary that there should be a reliable channel for transferring the trip to the remote end.

On any line, if to the usual double range directional distance protection, this transfer of the trip is added, instantaneous protection covering the whole line is obtained if the impulse gets through; if it does not, the distance protection is still effective in its usual form.

The limitations on this scheme are that it cannot be applied to very short lines, also that it depends on the channel for its effectiveness.

3. *Transfer Lock-out Scheme.*

One certain criterion of the soundness of a line section on a faulty system is that when power is entering one end of a line there must be power flowing out the other end. If a directional relay is used at each end, connected to close its contacts for outflowing power, one or other but not both of the relays will close its contacts when sufficient fault current is flowing through the line to an external fault. This action can be used to operate an auxiliary relay to lock-out (open) the trip circuit of the local oil circuit breaker of the line and to send an impulse over the pilot channel to lock-out the remote circuit breaker until the fault clears elsewhere. Fault detector relays at the respective end may then be used to trip the local breakers after a momentary delay sufficient to allow the lock-out to function if the fault is external. The essential features of this scheme are shown in Fig. 24b.

Dependence is placed on the passage of the lock-out impulse over the pilot in every case of external fault where the current is sufficient to operate the fault detector relays.

It is to be noted that relays which control the lock-out function must be more sensitive and faster under all circumstances than those which cause tripping; because in practically every system there will be external faults which will cause just sufficient current to start some of the relays, and the ones which start first must be the blocking relays. It is also to be noted that no irregularity of the performance of the blocking relays can be allowed to infringe on the momentary time delay before the tripping occurs.

In this arrangement, the infeeding fault current at each end is depended upon to trip the respective circuit breaker. This may lead to tandem tripping of the two ends under certain system conditions.

The scheme also has the disadvantage of not being strictly instantaneous, due to the time delay for "lock-out"—or "stabilizing".

This scheme has been used in Great Britain in at least two forms and recently tests on an American installation using carrier current pilot have been described.[4, 5] In this latter case the delay allowed for "lock-out" was 0.1 second.

---

[4] G. E. Review, November, 1932—Traver Auchincloss and Bancker.

[5] Electrical World, September 10th, 1932—Sporn and Muller.

4. *Combination Transfer of Lock-out and Trip.*

If to the Transfer Lock-out Scheme a second channel is added to interconnect the tripping functions so that the fault detectors at either end will trip both ends after the delay for stabilizing, simultaneous clearance can be obtained at both ends for any line fault with no chance of tandem action. This addition may be worth while on short important lines where tandem action is undesirable.

If the expense of carrier equipment for the pilot channel is warranted these schemes may be applied to lines of any length. They will have a wide field of application and their development constitutes an important advance in the art.

Branched or Tapped Lines.

In the development of a system the use of branched line sections would often permit of considerable saving in cost, and would be very convenient to use except for the fact they present a difficult relaying problem for anything approaching high speed in relaying, especially if branches are long or if there is synchronous equipment connected at more than two ends. For current relays, current balance relays and residual relays about the best that will be accomplished will be the opening of breakers on the ends of the branches in succession.

Distance protection is in general inapplicable because voltage and current at the relaying points are not functions of the distance to the fault because of the superposition of currents. It is applicable if the tap is to a transformer station without synchronous back-feed if the impedance of the bank is above the setting of the instantaneous ranges of the terminal relays.

However, power directional pilot schemes using methods 2, 3 or 4 are applicable and provide for the first time a satisfactory solution of the relaying problem on this type of line for high-speed clearance.

* * * *

VIII. STANDBY OR OVERLOAD PROTECTION.

We have seen that in order to obtain high-speed in the clearance of faulty elements of our system, the relays for any element pay no attention to external faults—with the solitary exception of the overlap of the timed distance range on long line protection to a limited distance beyond the remote end. There is no provision for clearing a fault on any section of the system not provided with instantaneous zone protection, nor for the case where the instantaneous relaying of a zone fails to complete the clearance due to deficiency in the relays or failure of the breaker to open. Some sort of back-up protection would seem to be required to take care of these two conditions so as to prevent the excessive damage which would occur in care the fault had to be located and cleared up by the operator.

The back-up relays should be arranged:

1. To split up the system into sections which are as far as possible balanced as between load and generating capacity. In any case they should divide it up so that as small a section as seems feasible containing

the faulty zone will be cut away from the main system.

This operation should be timed to give the zone and line protections some margin on the time necessary to function, which they will do properly in the great majority of cases.

2. To cut off all power supply to the section which is still hanging on to the fault after allowing time for the separation function to be performed.

The best separation points will depend on the system diagram and may change from time to time. In the case of a step-down station, the relays could well be on the transformer banks to clear them off in case of a persistent secondary fault.

Tripping off the generators will kill a system.

In general, it is desirable to arrange for the standby to trip a breaker other than the one whose failure has required it to operate.

The standby protection also acts to prevent continued over-loading although for that purpose probably some form of thermal relay will give the desired results more directly.

Relays for Standby Protection.

If sufficient fault current through the relaying point is always available, the induction excess current relay is ideal. However, such conditions do not usually prevail, for example, when applied to the output of a single generator such a relay must be given a surprisingly low time lever setting to get it to trip in 3 or 4 seconds.

The distance relay using direction if necessary and set to trip when carrying about 2 to 3 times maximum load current at rated voltage and with the necessary auxiliary timing has the advantage that it is practically independent of connected generator capacity and is quite satisfactory. It has the disadvantage that if the voltage is removed, it will trip at loads away below the normal value. Where such tripping must be avoided it is necessary to use two similar relays on the same current circuit but with potentials supplied from duplicate sources. In addition, if protection is to cover both sides of a delta-star transformer bank for 1-1 faults two double sets are required, one for the star side and one for the delta.

* * * *

IX. General.

We have seen that the most useful method to obtain complete and fast protection is to apply the protection to the elements or areas of the system—zones and lines—with suitable back-up. The more completely this is done the better. The ideal would be the system where the back-up protection could be omitted.

The general conception of the scheme is simple and in general, the relays are simple. If the protections were all of the instantaneous zone type or pilot type, there would be little requirement for co-ordination. Each protection would be fitted to its own element. It is really the portions of the equipment which is provided to take care of loop-holes in the protection or failures to operate which require co-ordination. In the change-over of a system from older types of relaying, there are places where the two types join together where there is difficulty in co-ordinating back-up relays using definite timing with those using inverse timing.

In order to get the full benefit of modern relaying, great attention to details is required to provide an installation which will give the desired results. Some points requiring attention are,—

The characteristics of current transformers, secondary wiring and relays must be studied to obtain the required sensitivity. This is important in all cases but it is acutely necessary in the case where the residual connection is used with 25 cycle bushing type current transformers. Fortunately, most high speed relays have inherent low impedance.

The relays must be selected with the desired characteristics, and the design must be such that these characteristics are permanent and accurate under all operating and fault conditions and they should be obtained without hair-trigger adjustments which are likely to change in operation.

In order to faciliate maintenance the layout of the relay panel requires consideration. Arrangement of relays, wiring and terminals should follow standard rules. Provision should be made for ready checking of circuits, and relays such as by provision of links, switches or test blocks. These must be of high grade so as to present a minimum hazard of open or short circuits in the wiring.

It is of the utmost importance that joints in current, potential and control wiring should be a minimum to prevent danger of open circuits. The workmen should appreciate the very great necessity for care in making joints and in installing the wiring and connections. The workmen and inspectors must be on the lookout for any condition which looks as though it might some day cause a failure of this wiring. A failure here may cause wrong trip-out of an element at an awkward time or it may lead to the failure of a breaker to trip which is much worse.

It is, therefore, necessary that ample information should be given to the construction and maintenance staffs so that they will thoroughly appreciate the value of very careful attention to the details of construction. This necessity is essentially not greater than in the case of other relaying methods, but the advantages of reliable operation of the instantaneous relaying is so great that all feasible care should be taken to ensure it.

After the installation is complete, the relay and oil circuit breaker maintenance staff bear the brunt of keeping it in working order which they usually find pleasure in doing if it is well designed and gives the required results.

The station operators have not much to do with a properly designed scheme except to understand what it should do and to take advantage of its benefits, report the relay indications accurately in case of trouble, and report any case where they do not think it is working correctly, especially any case of sluggishness or failure in opening a breaker.

On all important new construction, the writer firmly believes that the methods of high-speed relaying with the minimum necessary amount of back-up effect should be applied, and he believes this will become increasingly the practice all over this continent.

For smaller systems, these methods are applicable when applied with discretion.

On old stations they are desirable but usually expensive, not so much for the relays as for current and potential transformers, conduit and cable and cost of installation. This condition usually ends in a compromise with results which are not always all that could be desired. These old stations challenge the ingenuity of the Engineer to fit them in to a modern system at a tolerable cost.

Ontario Municipal Electrical Association and Association of Municipal Electrical Utilities

Report of Municipal Pension and Insurance Plan

This plan, as you know, was put into operation on May 1, 1929, after the Committee, which had been appointed to consider the possibilities of such a system, had spent some four years in investigations.

During that period the members of the Committee had many meetings, and conferences were held with representatives of leading insurance companies both in Canada and in the United States. Information had been secured from many sources in respect to pension and insurance plans, being carried on in various places all over the continent, and finally after all these data had been secured and compiled, specifications were drawn up combining what seemed to be the best features of the various plans, and making certain additions which the committee believed to be of material advantage to our own particular needs.

The Life Underwriters Association was then notified that any companies wishing to consider this proposal could secure copies of the specifications and submit plans. And finally the contract was entered into between the Hydro-Electric Power Commission of Ontario acting on behalf of the Municipal Authorities and the Insurance Companies composed of a combination of the Confederation Life Association, the London Life Insurance Company of Canada, and the Mutual Life Assurance Company of Canada, which not only provided absolute security but which also gave the municipality and employees most favourable terms.

The policies under this contract provide for three classes of benefits.

1. A monthly Pension on attaining age sixty-five payable during the employees life time.

2. Insurance payable at the death of the employee to the beneficiary of such employee of a stipulated amount, payable either in a single sum or in installments as arranged.

3. Payments of the monthly Pension and the waiver of all future premiums in the event of total and permanent disability of any employee.

These benefits are provided for by monthly premiums paid jointly by the employee and the local Commission which is called the Municipal Authority, and the local Commission paying about two-thirds, and the employee about one-third of such premiums. It was felt at the beginning of this movement and has been proven by the operation of similar plans in other organizations that a system such as this establishes a sense of security in the minds of employees that makes for contentment, a greater percentage of efficiency and a very considerable decrease in labor turnover.

While this plan has been taken advantage of by nearly all the larger municipalities as well as a considerable number of the smaller ones, comprising altogether about two-thirds of the total number of employees, it is felt that all other commissions who can possibly do so should take advantage of this plan which offers a maximum of security at a minimum cost and which would not be possible by Municipalities operating separately. The standing to January 1st, 1933, is as follows:—

1.	Number of Municipalities included	45
2.	Number of Employees included	2,094
3.	Amount of Life Insurance Benefit in force	$4,370,550
4.	Amount of Monthly Service Annuity Pension being purchased	$94,412
5.	Amount of Monthly Income Annuity Pension being purchased	$54,558
6.	Number of Employees at present drawing Pension	11
7.	Amount of Monthly Pension being paid	$177
8.	Number of Employees who have reached the Normal Retirement Age but have been retained in employment	18
9.	Amount of Monthly Pension being paid into Joint Deposit Account, with reference to those employees who have reached their Normal Retirement Dates and who have been retained in employment	$209
10.	Amount of Municipal Authority's 5% monthly payment	$14,320
11.	Amount of Employees' monthly Income Annuity Payment	$7,429
12.	Amount of Employees' monthly Extra Contribution	$215
13.	Number of Death Claims to January 1, 1933	39
14.	Amount of Death Claims to January 1, 1933	$75,570
15.	Amount of Employees' Income Annuity Contributions refunded	$12,225
16.	Amount of Employees' Extra Contribution refunded	$540

T. J. HANNIGAN,
Secretary

Association of Municipal Electrical Utilities

Auditors' Report

Statement of Receipts and Disbursments for Year Ending December 31st, 1932.

Receipts

Cash in Bank, Dec. 31, 1931		$ 559.99
Receipts		
Membership Fees:		
Municipal	$1,433.00	
Commercial	430.00	1,863.00
Convention Receipts		1,978.00
O.M.E.A. Contribution		122.07
Interest on Bonds:		
Dom. 1959, 4½%, Conversion Loan		22.50
Dom. 1934, 1%, re Conversion Loan		5.00
Prov. of Ont. 1948, 5%		50.00
Interest on Deposits		26.69
		$4,627.25

Disbursements

Convention Expenses:	
Dinners and Luncheons	$1,838.00
Entertainment	285.18
Reporting	175.70
Printing	315.69
Badges	83.20
Miscellaneous	123.17
	$2,820.94
Travelling Expenses	355.15
Remuneration, Secretary	150.00
" Treasurer	125.00
Printing and Stationery	116.09
Bank Exchange	28.50
Postage	53.80
Miscellaneous	39.10
Balance in Bank	938.67
	$4,627.25

Assets

Cash in Bank		$ 938.67
Dominion, 1959, 4½% Bond		500.00
Prov. of Ont., 1948, 5% Bond		1,000.00
Projecting machine	$243.45	
Less Written Off	193.45	50.00
		$2,488.67

We certify that the above statements disclose the true condition of affairs of the Association as shown by the books and vouchers covering the year ended December 31st, 1932.

Sgd. W. G. Pierdon,
H. P. L. Hillman,
Auditors.

* * * *

Minutes of Convention

The thirty-second Convention of the Association of Municipal Electrical Utilities opened at the Royal York Hotel, Toronto, at 11.00 o'clock on the morning of Tuesday, January 24, 1933. The President, Mr. C. E. Schwenger, as Chairman, welcomed the delegates to the Convention.

Mr. O. H. Scott, Chairman Merchandising Committee, presented a report from that Committee. Mr. H. F. Shearer drew attention to the cheap imported lamps retailed by Chain Stores and asked that the following clause be added to the report,

"THAT we go on record, advising the Sales Department of the Hydro-Electric Power Commission to obtain samples of the imported lamps and make all the necessary tests in order that the data thus

obtained may be available to the various utilities for the purpose of combatting the present propaganda behind the cheap imported lamp."

Mr. Scott agreed to having this clause added to the Committee report.

Mr. J. W. Peart, Chairman, Regulations and Standards Committee, advised that he had no report.

In the absence of Mr. J. E. Skidmore, Chairman, Committee on Accident Prevention and Health Promotion, the President referred to a meeting held the preceding day under the auspices of the Electrical Employers' Association, and attended by members of the Committee, and asked Mr. Wills Maclachlan for a verbal report. Mr. Maclachlan advised that there had been a decrease in the number of accidents and that there had been three cases of successful resuscitation from electrical shock during the past year. He reported progress for the Committee and hopes to have a report for the Summer Convention.

As Mr. W. R. Catton, Chairman, Rates Committee, was not present, the President asked Mr. P. B. Yates to report. He advised that there had been a meeting and referred to some of the details discussed. The Secretary read a letter from Mr. Catton that gave a brief summary of recommendations from the meeting for consideration of the Executive Committee.

The Auditors report showed the Association to have started the year with a bank balance of $559.99, and finished with $938.67. Receipts and disbursements amounted to $4,627.25, and the assets of the Association, $2,488.67.

The Secretary presented the names of L. W. Pratt, S. K. Cheney and Gordon B. Tebo for election as Associates, and Federal Wire and Cable Company, Limited, Guelph, as Commercial member.

It was moved by Mr. E. I. Sifton and seconded by Mr. J. E. B. Phelps, THAT these candidates for membership be accepted.—*Carried.*

The Secretary read letters of invitation from various sources regarding the holding of the Summer Convention, and advised that they would be considered at an Executive Committee meeting to be held that evening and reported on at the Convention session on the following day.

The session then adjourned.

At 12.30 p.m. the delegates met with the Ontario Municipal Electrical Association for the first Convention luncheon, with Mr. C. E. Schwenger, President, Association of Municipal Electrical Utilities, as toastmaster. The Honourable Charles McCrea, Minister of Mines for the Province of Ontario introduced the Right Honourable Arthur Meighen, P.C., K.C., guest speaker, who gave an address on "Money".

The second session of the Convention opened at 2.30 p.m.

The President declared the ballot for the election of officers for 1933 closed, and delegated Messrs. T. R. C. Flint and T. C. James scrutineers to count the ballots.

Mr. D. W. McLenegan, Assistant Engineer, Commercial Engineering Division, Air Conditioning Department, General Electric Company, Schenectady, N.Y., presented a paper

entitled "Air Conditioning from the Electric Utilities Standpoint".

Mr. G. W. Austin, Manager, Electric Service League, Toronto, presented a paper "The Central Station's New Responsibility".

Mr. Joseph Showalter, Canadian Westinghouse Company, Limited, Toronto, presented a paper "Making More Use of Our Low Cost Power".

Discussion following these three papers was by Messrs. O. W. Titus, A. S. L. Barnes, E. V. Buchanan, A. H. Frampton, M. P. Whelan, George G. Cousins, A. W. J. Stewart, and O. M. Perry.

The President extended to Messrs. McLenegan, Austin and Showalter the thanks of the Convention for bringing to it such interesting and valuable papers.

The results of the elections of officers for 1933 were announced as follows:—

PRESIDENT—T. W. Brackinreid, Port Arthur.

VICE-PRESIDENT — W. R. Catton, Brantford.

SECRETARY — S. R. A. Clement, H.E.P.C. of Ont., Toronto.

TREASURER — D. J. McAuley, H.E. P.C. of Ont., Toronto.

DIRECTORS—(from the membership at large)—E. V. Buchanan, London; O. M. Perry, Windsor; and O. H. Scott, Belleville.

DISTRICT DIRECTORS—

NIAGARA DISTRICT: R. S. Reynolds, Chatham.

CENTRAL DISTRICT: G. E. Chase, Bowmanville.

GEORGIAN BAY DISTRICT: R. S. King, Midland.

EASTERN DISTRICT: M. W. Rogers, Carleton Place.

NORTHERN DISTRICT: C. J. Moors, Fort William.

The session then adjourned.

The Association met at 6.30 p.m. with the Ontario Municipal Electrical Association for the Convention dinner. After a musical programme Mr. C. A. Maguire, President, O.M.E.A., as toastmaster, introduced Sir Alfred Morine, K.B., K.C., guest speaker, who gave an address on the Ottawa Economic Conference.

The third session of the Convention opened at 9.30 on the morning of Wednesday, January, 25th.

Mr. R. T. Jeffery, Chief Municipal Municipal Engineer, Hydro-Electric Power Commission of Ontario, gave an address outlining a plan for load building by promoting use of flat rate water heaters.

At 11.00 o'clock the meeting became a joint session with the Ontario Municipal Electrical Association with Mr. W. Ellis, Vice-President O.M.E.A., in the chair.

Mr. T. J. Hannigan presented a report on the Pension and Insurance scheme of the Municipal Utilities.

Mr. F. A. Gaby, Chief Engineer, Hydro-Electric Power Commission of Ontario read a paper "Hydro Progress during 1932."

The Chairman submitted a recommendation from the A.M.E.U. Executive Committee to hold the Summer Convention at Windsor on June 22, 23 and 24. This was approved.

The session then adjourned.

At 12.30 p.m. the Association met with the Ontario Municipal Electrical Association and the Electric Club of Toronto for the second Convention luncheon, with Mr. C. E. Schwenger, President, A.M.E.U. as toastmaster,

Mr. T. L. Church introduced the guest speaker, the Honourable and Reverend H. J. Cody, D.D., LL.D., President, University of Toronto.

The fourth session of the Convention opened at 2.30 p.m. when Mr. S. M. Dean, Chief Assistant Superintendent of Electric Systems, The Detroit Edison Company, Detroit, Michigan, presented a paper entitled "Mere Distribution". Discussion following Mr. Dean's paper was by Messrs. E. V. Buchanan, the President, A. G. Lang, V. A. McKillop and G. L. Lillie.

The President, on behalf of the Association, thanked Mr. Dean for his trouble and work in preparing his paper and for coming and presenting it.

The meeting was then thrown open for a discussion of the proposal outlined at the morning session by Mr. R. T. Jeffery, regarding load building by encouraging flat rate water heaters. Those taking part in the discussion were Messrs. E. V. Buchanan, J. W. Peart, H. J. MacTavish and A. S. L. Barnes.

At this point it was recognized that the time was getting late, although there were yet two papers on the programe to be heard. These papers were "The Starting of Polyphase Induction Motors from the Electric Utility Viewpoint" by Wilson J. Wylie, Toronto Hydro-Electric System and "Wood Poles—Loading and Strength" by S. K. Cheney, H.E.P.C. of Ontario. It was suggested that these two papers be laid over until the Summer Convention. The President asked for an expression of opinion on this. It was moved by Mr. J. W. Peart and seconded by Mr. E. V. Buchanan THAT these two papers be laid over for the Summer Convention.—*Carried.*

The President thanked the members of the various Committees for the work done and the efficient manner in which they had carried on in arranging for a successful Convention.

The Convention then adjourned.

The register shows a total of 536 delegates to have attended the Convention, classified as follows:—

Class A	102
Class B	226
Commercial	99
Associates	55
Visitors	54

There were 526 present at the Convention luncheon on Tuesday, January 24th, and 493 at the Convention dinner on the evening of that day. At the Convention luncheon on Wednesday, to which the Electric Club of Toronto was invited, there was a total attendance of 570.

* * * *

Minutes of Executive Committee Meeting

A meeting of the Executive Committee of the Association of Municipal Electrical Utilities was held at the Royal York Hotel, Toronto, on the evening of Tuesday, January 24th, 1932. The meeting was called to order by the President, T. W. Brackinreid at 10.00 p.m. Other Executive officers were Messrs. G. E. Chase; W. R. Catton; R. S. Reynolds; O. M. Perry; C. J Moors; O. H. Scott; M. W. Rogers; R. S. King; C E. Schwenger; D. J. McAuley; T. J. Hannigan and S. R. A. Clement.

Suggested meeting places for the

1933 Summer Convention referred to by correspondence presented and representatives received , were considered as follows,—

A letter from Charles O. Shaw, President, The Bigwin Inn Company, quoted rates offered by that hotel and suggested dates available. Mr. S. Forsythe, Assistant Manager, was present and elaborated on the information given in the letter, and also answered questions of the members.

Letters from the Border Chamber of Commerce, Prince Edward Hotel, and Hotel Norton-Palmer, Windsor, suggested Windsor for the Summer Convention. Mr. Davis of the Chamber of Commerce and M. R. Gilbert, Manager, Prince Edward Hotel, outlined the facilities offered and dates available.

Mr. J. R. Beck, District Passenger Agent, Canadian Steamship Lines Limited, suggested a boat trip from Windsor to Port Arthur and return, quoting rates and a proposed schedule.

Mr. E. V. McGuire, Resident Manager, Hotel General Brock, Niagara Falls, spoke on behalf of Niagara Falls for the Convention, using his hotel as Convention headquarters.

Mr. S. M. Green, General Agent—Canadian National Railways, extended an invitation to hold the Summer Convention at the Chateau Laurier, Ottawa, referring to a proposal that had been submitted by letter.

After discussions of the various invitations and proposals, it was moved by Mr. W. R. Catton and seconded by Mr. O. H. Scott—THAT this Committee recommend to the Convention, during the joint session with the Ontario Municipal Electric Association on the following morning, THAT the Summer Convention be held at Windsor on June 22nd, 23rd and 24th, 1933.—*Carried.*

Standing Committees for 1933 were then drafted, the following being approved:—

Papers Committee:—E. V. Buchanan, London, Chairman; C. E. Schwenger, Toronto; S. McCordick, Moloney Electric Company of Canada, Toronto; Joseph Showalter, Canadian Westinghouse Company, Toronto; and W. P. Dobson, H.E.P.C. of Ontario, Toronto.

Convention Committee: — Messrs. W. R. Catton, Brantford, Chairman; O. M. Perry, Windsor; D. B. McColl, Walkerville; V. A. McKillop, London F. Mahoney, Canadian General Electric Company, Toronto; C. H. Hopper, Ferranti Electric, Toronto; R. H. Starr, G. F. Drewry and J. W. Purcell, H.E.P.C. of Ontario, Toronto

Regulations and Standards Committee:—Messrs. C. E. Schwenger, Toronto, Chairman; J. W. Peart, St. Thomas; W. J. Jackson, London; R. J. Smith, Perth; P. B. Yates, St. Catharines; E. I. Sifton, Hamilton; F. W. Peasnell, Toronto; W. P. Dobson, H.E.P.C. of Ontario, Toronto, and A. G. Hall, Electrical Inspection Department, Toronto.

Committee on Accident Prevention and Health Promotion:—Messrs. G. E. Chase, Bowmanville, Chairman; J. E. Skidmore, Cobourg; H. G. Hall, Ingersoll; R. S. Reynolds, Chatham; E. J. Stapleton, Collingwood; J. W. Peart, St. Thomas; C. A. Walters, Napanee; V. A. McKillop, London; F. D. Hubbell, Windsor; T. C. James, G. F. Drewry, E. R. Lawler and Wills

Maclachlan, H.E.P.C. of Ontario, Toronto.

Merchandising Committee:—Messrs. O. H. Scott, Belleville, Chairman; J. E. B. Phelps, Sarnia; F. S. Rhoads, Windsor; W. H. Childs, Hamilton; I. N. Pritchard, Chatham; H. F. Shearer, Welland; A. W. J. Stewart, Toronto, and G. J. Mickler, H.E.P.C. of Ontario, Toronto.

Rates Committee:—Messrs. O. M. Perry, Windsor, Chairman; P. B. Yates, St. Catharines; E. I. Sifton, Hamilton; V. S. McIntyre, Kitchener; C. E. Schwenger, Toronto; T. W. Brackinreid, Port Arthur; E. V. Buchanan, London; O. H. Scott, Belleville; R. S. Reynolds, Chatham; G. E. Chase, Bowmanville; R. S. King, Midland; M. W. Rogers, Carleton Place; C. J. Moors, Fort William; D. J. McAuley and S. R. A. Clement, H.E.P.C. of Ontario, Toronto.

Committee on Accounting and Office Administration: — Messrs. M. W. Rogers, Carleton Place, Chairman; R. L. Dobbin, Peterborough; D. B. McColl, Walkerville; W. H. Childs, Hamilton; A. B. Manson, Stratford; I. N. Pritchard, Chatham; W. E. Wallace, Windsor; R. S King, Midland; H. Clegg, Peterborough; A. L. Farquharson, Brockville; George Appleton, Toronto; G. F. Drewry and R. M. Bond, H.E.P.C. of Ontario, Toronto.

Auditors:—Messrs. H. P. L. Hillman, Toronto and W. G. Pierdon, H.E.P.C. of Ontario, Toronto.

Moved by Mr. C. E. Schwenger and seconded by Mr. O. M. Perry,—"THAT the Secretary and Treasurer be paid, as an honorarium, amounts the same as granted last year."—*Carried.*

The meeting then adjourned.

Reducing Kite Flying Hazards

SPRING, with its fine breezy weather, is here.

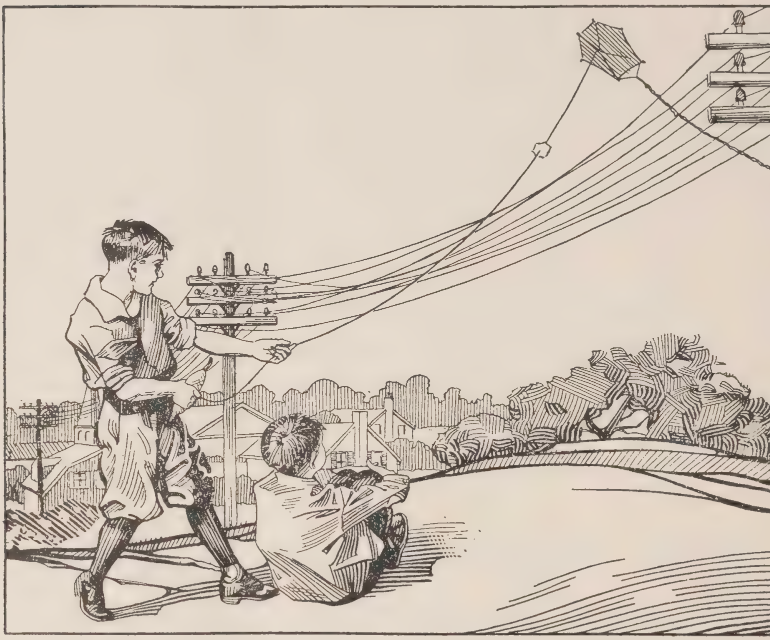
The younger generation has again awakened to the call of kite flying. Every care should be taken against their becoming exposed to danger on account of the proximity to electrical transmission and distribution lines. It is therefore timely that an early warning be sent out, giving instructions re the safe construction and flying of kites.

Fatalities from kites coming in contact with the Commission's lines have been very rare, though several fatalities have occurred on other electrical properties. Fatalities have, however, occurred by the victims climbing poles or structures to release a kite entangled in the power wires. Also, numerous cases of trouble have been reported on the System, caused by kites becoming attached to the structures or cables, causing interruptions to service and damage to equipment.

On several occasions the Hydro-Electric Power Commission has distributed literature warning school children of the dangers of kit flying and about a year ago, the Commission, in co-operation with the Toronto Hydro-Electric System, prepared two pamphlets, which they distributed in the schools of Toronto and vicinity. One of these "ADVICE TO SCHOOL

YOUR KITE STRING MAY KILL YOU!

DO YOU BOYS REALIZE THE DANGER OF FLYING KITES NEAR WIRES CARRYING ELECTRICITY?



This boy probably will be seriously burned, maybe killed, if his kite string touches the electric wires. There is a chance that he may escape harm if the string is not wet and contains no metal thread, provided he does not get too near the wires. If he has a damp or wet string, or a string containing a small metal thread, or a wire instead of a string, he will surely be hurt and perhaps killed.

It is Dangerous and Very Foolish to Fly Kites Near Electric Power Lines

Reproduction of poster (original on 8½ by 11 in. sheet).

CHILDREN" gives nine brief safety rules as follows:—

1. Avoid touching any wire you see hanging from a pole or tree or lying on the ground.

It may harm you or electrocute you. A good lineman never touches a wire until he is certain that the electricity has been cut off.

2. Keep off poles and towers.

3. Keep out of trees through which wires pass.

4. Do not touch or swing on guy wires. These are the wires attached to a pole and to anchors in the ground, or to another pole.

They may accidentally carry a dangerous current.

5. An insulator broken by the stone you throw may injure men working in the power stations.

6. Do not fly kites across wires, touch or handle a string hanging from the wires.

7. Keep away from poles on which men are working.

8. Keep away from switching towers, sub-stations and power houses.

9. Telephone the nearest office or power station of the Hydro-Electric Power Commission if you see an insulator broken, a broken wire hanging down from a power line or a string or kite tangled in the power wires. They will be glad to receive the information.

The second pamphlet was in the form of a poster and is reproduced in the accompanying illustration.

A letter addressed "To The Teacher" was prepared. To this letter was attached a piece of tinsel string. Its hazard was pointed out and some of the dangers incidental to kite flying, were enumerated. A request was made asking the teacher to display the poster to her class and read "Advice to School Children."

This letter was personally delivered to the school by an employee of one of the Commissions. The contact thus made was of great value.

Copies of either of the pamphlets may be obtained from THE BULLETIN at 30c. per hundred.

The recent crusade against vendors of unapproved Christmas tree lighting sets is particularly interesting when authentic accounts are now to hand covering the disastrous fire in Tokio, Japan, which caused the loss of fourteen lives, the injury of 100, and a property loss of $4,000,000.

This fire took place on December 16th last, just about the time that violators of the Rules and Regulations were being prosecuted here, and strange to say for selling Japanese Christmas tree sets.

Quoting from the quarterly of the National Fire Protection Association, we read as follows:—

> "Suddenly on the third floor a Christmas tree decorated with electric lights burst into flames, maybe from a short circuit."

Some of the Requirements governing approval may seem far fetched to the uninformed purchaser, but here is an object lesson worthy of note.

—*H.F.S.*

La Salle Hydro-Electric System would be glad of any information as to the present address of Mr. Earl B. Wilkinson.

THE BULLETIN

Published by

HYDRO-ELECTRIC POWER COMMISSION of Ontario

620 University Ave. Toronto

Subscription Price $2.00 Per Year

General Description of The Chats Falls Development and Organization for Construction

By T. H. Hogg, D. Eng., M.E.I.C., Chief Hydraulic Engineer, H.E.P.C. of Ont.

(Paper presented at the General Professional Meeting of the Engineering Institute of Canada at Ottawa, Ont., February 8, 1933.)

THE Chats Falls development is the first major power development on the interprovincial section of the Ottawa River which constitutes a complete development of the whole flow at any site. Other important developments are those at the Quinze, Bryson and Ottawa. The first of these latter plants, which has a capacity of 40,000 h.p., is above Lake Timiskaming and consequently entirely within the Province of Quebec. The Bryson development is on the interprovincial section of the river, but, as the river is here divided into two channels by Calumet island, and the interprovincial boundary follows the larger channel, the development on the eastern channel is entirely in the Province of Quebec and, furthermore, is not a complete development of the river. At Ottawa, the Chaudiere dam spans the whole width of the river and controls the head water for a number of independent plants located in either province, but only part of the potentiality of the river is used here.

There are numerous developments on the tributaries, some of great size, as on the Gatineau, Lievre, Kipawa and Madawaska Rivers.

Throughout the interprovincial section of the river there are numerous undeveloped sites, many of them of great potentiality and, for the most part, capable of economical development. Remoteness of markets for the output of the larger among these had precluded development up to the present time.

The Ottawa River

The Ottawa River has had a colourful history. It was a most important route of travel as early as three centuries ago. It was for a long time

CONTENTS

Vol. XX No. 4
April, 1933

the main route of trade with the Indians to districts north and west of its own watershed. More recently it has seen lumbering developments on a vast scale, and important pulp and paper manufacturing establishments are now located on the main stream and its tributaries. Extensive mining developments have taken place in adjacent territory. Important storage developments have been built for the benefit of lumbering and for water power, particularly on tributary streams.

The portion of the river developed at Chats Falls is that between Chats Lake and Lake Deschenes. These lakes are formed by two expanses on the river and have areas of 27 and 36 square miles respectively. Uniting them is a channel about 3 miles in length, in which there was a natural fall of 50 feet, 38 of which occurred at Chats Falls at the lower end of the 3-mile channel, and the remainder in the rapids above the Falls. The rapids and falls are separated by a broad expanse in the river known as Fishery Pool, having an area of approximately one square mile, which now forms the forebay of the development. The falls discharge directly into Lake Deschenes. The river channel at the crest of the falls was divided by islands into a number of chutes extending diagonally across the main course of the stream, the chutes at the two extremities being some two miles apart.

There were obtained at various times, rights to develop power on individual chutes or on groups of chutes. Some of these rights existed fifty or more years ago, and, on account of the difficulty in obtaining complete co-operation among the various interests involved, development on a comprehensive scale was retarded. Certain properties and development rights were obtained on the Ontario side by the late Honourable Mr. Harty as early as 1883, and these, along with others held by Mr. D. O'Connor, of Ottawa, with whom Harty had become associated, were expropriated by the Hydro-Electric Power Commission in 1912. This expropriation, along with the purchase, or expropriation, of other properties and minor rights, placed the Commission in complete control of all Ontario rights of development, that is to say, as far as the interprovincial boundary.

Certain proposals for development of that part of the site lying in the province of Quebec were under consideration at various times, and surveys and reports were made. In fact, on one of these, construction had proceeded to a certain extent. Prior to this, of course, all development rights on the Quebec side of the boundary had been combined and a development license obtained from the Quebec government.

By courtesy of Canadian Airways Limited

Fig. 1—Aerial View of Chats Falls Development.

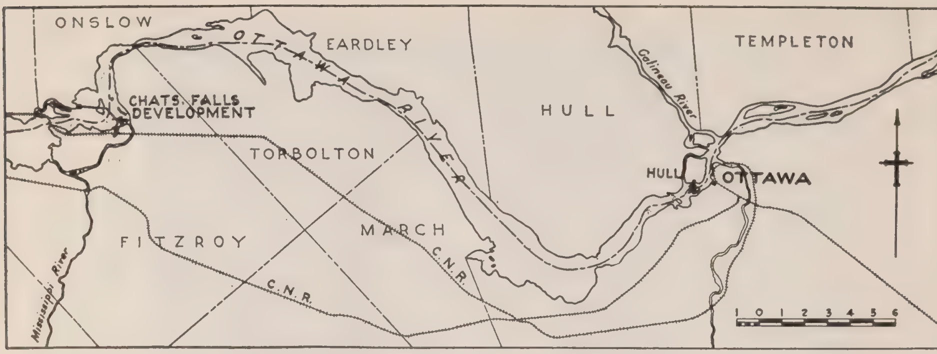


Fig. 2—Location of Chats Falls Development.

Some years ago, the Chats Falls Power Company, now known as the Ottawa Valley Power Company, was formed and proceeded with surveys and plans for a development that would place a power house at Egan Chute, with a dam to a point on the Ontario shore upstream from Fishery Pool. This development would, of course, use only half the flow of the river. An agreement was made in 1928 between this company and the Hydro-Electric Power Commission for a development of the whole site in one power house. The agreement provided for the organization described later, and was followed by the completion of a contract whereby the Hydro-Electric Power Commission purchased that half of the power belonging to the Ottawa Valley Power Company. Surveys and engineering studies proceeded forthwith, and construction commenced in the fall of 1929. Four units were operating by the fall of 1931, and four more a year later. Headworks have been constructed for two additional units, the completion of which is contingent on the construction of additional storage works to further increase the minimum dependable flow.

The Ottawa river rises in Quebec about two hundred miles east of the interprovincial boundary, and thence flows westerly to enter Lake Timiskaming at its northerly extremity. The course of the river here changes to a southerly and southeasterly direction until the confluence with the St. Lawrence river is reached. From the northerly end of Lake Timiskaming to Carillon, about twenty-five miles above the junction with the St. Lawrence river, it forms the boundary between the provinces of Ontario and Quebec. The district in which it rises is a maze of rivers and lakes, not yet completely mapped. Here close together are found the sources of the St. Maurice and Gatineau rivers the latter draining Lake Cabonga through one of its main branches, while another outlet of the lake finds its way northerly to the main river. At Chats Falls the river drains an area of 34,000 square miles, and has received the outflow of many large tributaries, the most important among which are the Kipawa, Desmoine, Black and Coulonge from the north, and the Montreal, Petawawa, Bonnechere, Madawaska and Mississippi rivers from the west and south.

The enormous number of lakes found on all the tributaries and the lake-like expanses on the Ottawa play a large part in natural regulation of the flow of the river, and serve to maintain a relatively high minimum flow. Storage dams at Lakes Timiskaming, Kipawa and Quinze, along with the many smaller reservoirs on tributaries, serve to maintain a high dependable flow. Flood flows would doubtless be greatly in excess of those experienced were it not for the regulating effect of these reservoirs, natural and artificial. The fact also that the southern tributaries come into flood in the spring before the northern tributaries, has an important bearing on the size of the spring floods. The low ratio of maximum to minimum, or mean, flow experienced on the Ottawa river is, of course, characteristic of many more rivers in northern Ontario and Quebec.

Salient data regarding flow of the Ottawa river at Chats Falls are given in the following table:

Area drained....	34,000 square miles
Period of flow records..	17 years
Mean flow............	45,000 c.f.s.
Dependable minimum regulated flow......	22,000 c.f.s.
Minimum recorded flow	11,000 c.f.s.
Maximum recorded flow	200,000 c.f.s.

In addition to the above figures, it should be noted that the dependable minimum flow may be increased eventually to 28,000 cubic feet per second by the extension of storage facilities on the main stream and tributaries. The area of Chats Lake, 27 square miles, provides local pondage to care for daily and weekly variations in load.

DESCRIPTION OF THE DEVELOPMENT

The interprovincial boundary at the crest of Chats Falls passes through what was known as Mohr Chute. This was the most suitable point at which to locate the power house, as, with raised forebay level, a deep forebay was formed without the necessity of excavating any approach channel, and on the downstream side very little tailrace excavation was required. There was the added advantage that it was possible at this point to construct a single power house, subject to equal provincial control by the provinces of Ontario and Quebec, without requiring an officer of either province to go beyond his rightful jurisdiction. An aeroplane view of the river at the site, upon which are superimposed the principal structures of the development, is shown in Fig. 3.

To the right of the power house, that is to say on the Ontario shore, there are, in turn, a gravity section of dam some 1,200 feet in length; thirty-two stop-log sluices, each with a clear opening of 18 feet, known as the Ragged Chute sluices; a gravity section 1,350 feet long; the Victoria sluices, ten in number, also with 18-foot clear opening; and a further gravity section of 1,450 feet. Beyond this point it was necessary to continue the dam as a low earth dyke, parallel with the shore of the river, for 4,600 feet upstream. A section of the Canadian National Railway, two miles in length, which was crossed by the earth dyke, was relocated a short distance inshore.

Immediately to the left of the power house there are four sluices each 40 feet in width, equipped with steel gates of the fixed roller type. Beyond

Fig. 3—Mosaic of Power Site showing location of structures.

these is a log slide, a gravity section of dam 2,000 feet long, the Wolverine sluices, ten in number, a further gravity section of 650 feet, twenty-two Merrill island sluices, and finally a gravity section 2,600 feet long, ending in a number of small disconnected sections closing low spots some distance up the Quebec shore.

The Mississippi river enters the lower end of Chats lake. A high water channel, known as the Mississippi Snye, leaves the tributary half a mile upstream from its mouth, and enters the Ottawa River below the falls. Two small concrete dams, in one of which are two sluices, were required to control the flow in the Snye.

At the control at the outlet of the lake, about three miles above the power house site, channel improvements were made whereby it is possible to maintain Chats lake levels below natural levels at high flows, in spite of raised levels at the power house. These improvements and the dams on the Mississippi Snye are beyond the area covered by Fig. 3.

Immediately to the right of the power house, abutting on a gravity section of the dam, is a concrete platform, upon which thirteen single-phase transformers, 13.2-kv. to 220-kv., are erected, and about 800 feet from the Ontario end of the power house is the 220-kv. switching station, occupying an area about 300 feet by 360 feet. In this area are located nine oil circuit breakers and motor operated disconnecting switches. This provides for the leads from four banks of transformers, with space for leads from a fifth bank, and for two outgoing lines, with space for a third.

In Fig. 4 a general plan of the power house and the adjacent areas, including the transformer station, is shown. Descriptions of the power house layout and its equipment are given in other papers of this series.

Organization

The Ottawa being an interprovincial river, equal jurisdiction at the site is held by the provinces of Ontario and Quebec. To develop the site effectively, therefore, it was necessary that there should be cordial and close co-operation among a larger number of organizations than is usually the case in projects of this kind.

The site lent itself readily to an economic development, in which the power house crossed the interprovincial boundary, and made possible the use of a single control room and operating staff. Possible vexatious difficulties, that would arise in the operation of two independent power plants during periods of deficient water supply, were precluded. Such arrangements as to operation were more readily made because of the sale of the whole output of the Quebec half of the development to the Hydro-Electric Power Commission of Ontario.

The difficulties attendant on the construction and operation of such a joint development were not easy of solution, but the organization that was set up for the purpose functioned smoothly and effectively throughout. The general results were such that it is considered a description of the organization is warranted.

By an agreement between the Commission and the Ottawa Valley Power Company, two Boards were set up, known as the Executive Board

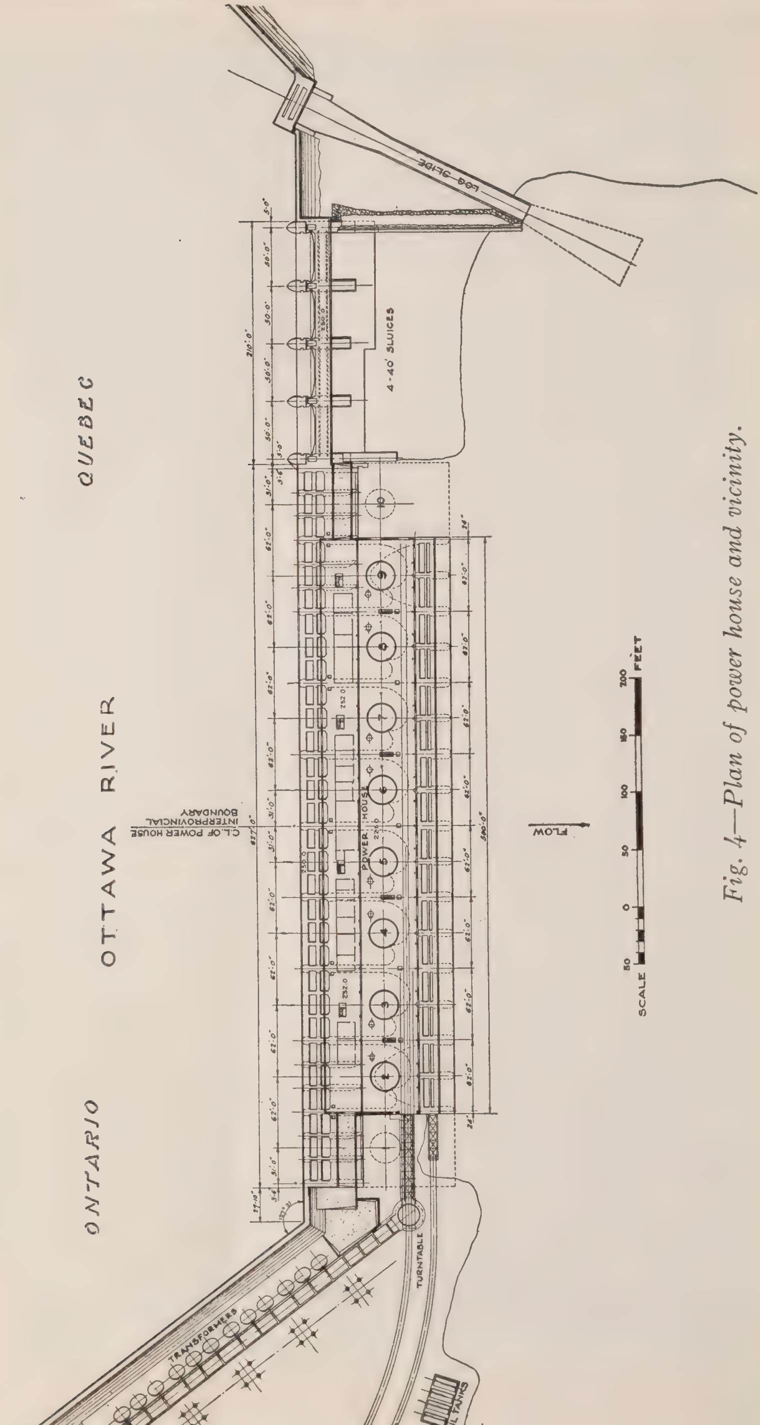


Fig. 4—Plan of power house and vicinity.

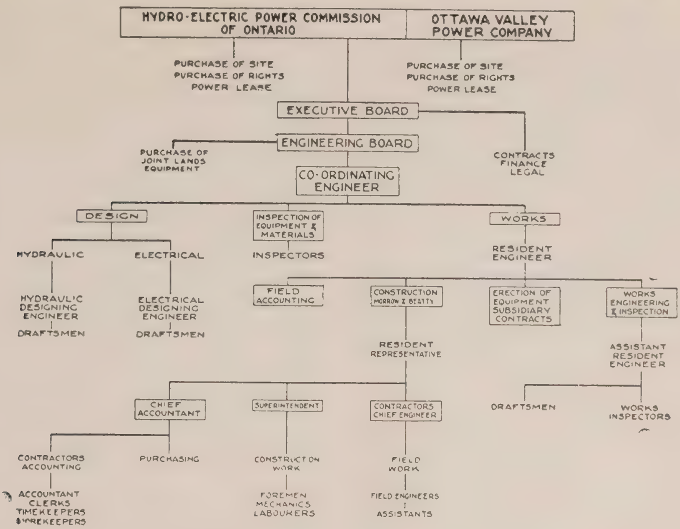


Fig. 5—Organization Chart

and the Engineering Board. Each of these consisted of four members, half being appointed by the Commission and half by the company.

The Executive Board, of which Dr. F. A. Gaby, M.E.I.C., was appointed chairman, was charged with decisions on matters of policy in connection with the acquisition of properties and construction of joint works, approval of plans and letting of contracts, administration of funds for joint expenditures, employment of staffs and experts, and to supervise generally the carrying out of the joint works and to deal with all contingencies connected therewith. It was empowered also to delegate to the Engineering Board such of its powers as it saw fit.

The Engineering Board, of which the writer was chairman, was charged with the preparation of plans and specifications, and supervision of construction of all joint works, the organization of the engineering, accounting, inspection and purchasing staffs, the recommendation of all proposed contracts to the Executive Board, and other duties especially delegated to it from time to time.

The organization chart in Fig. 5 shows the relationship of the two principal organizations and their subsidiaries. All instructions from the Engineering Board were passed to a co-ordinating engineer, and thence as indicated on the chart. This concentration of responsibility in one person reporting to the Engineering Board operated very smoothly and effectively. Frequent meetings of the Engineering Board and careful attention to the transmission of information to its members in intervals between meetings enabled the Board to base its decisions on continuous knowledge and study of the problems in hand.

As the Commission had a well organized engineering and designing

staff, this was used on the development, suitable arrangements being made as to compensation of the Commission by the Executive Board for these services. The inspection staff and laboratories of the Commission were also used.

Contact with the contractor and all parts of the field organization was entirely through the resident engineer at the works. The contractor's organization is also outlined in Fig. 5.

Apportionment of Costs

The Commission obtained from the Ontario government a lease of the residual water power rights in Ontario at the site, and by purchase, or expropriation, certain prior rights. The water power rental is payable to the province of Ontario by the Commission, not by the development as a whole. In the same way, the Ottawa Valley Power Company obtained a lease of the power rights in Quebec not already granted by the province of Quebec, and, by purchase, all other rights at the site. The Quebec rentals are payable by the company.

The Commission acquired, at its own expense, all necessary lands and rights in Ontario from tailwater to Chats lake, and, similarly, the company acquired all necessary lands and rights in Quebec between these limits. Lands and rights on Chats Lake were treated as joint lands, and were paid for equally by the company and the Commission. By the agreement, all lands however acquired in Ontario became the property of the Commission, and those in Quebec became the property of the company.

For the purpose of construction, all works, with the exception of the transformer and switching stations and operators' cottages, were treated as joint works, and the costs were shared equally by the company and the commission.

By the agreement, on completion of construction, the dam, power house headworks, all railways and roads, are to be treated as joint works, and the power house and power house equipment as separate works. Thereafter, until the expiry of the agreement, the Executive Board will maintain and operate the joint works for the mutual benefit of both parties, whereas the company and the Commission may deal as each sees fit with its own separate works.

General Results

The estimated cost of the development and the continuity of river flow were such as to make the project appear very attractive. Unusual conditions as to river discharge and stage and favourable weather during the whole period of construction resulted in appreciable savings in some of the expected expenditures. The maximum flood flow during the year 1930 amounted to 106,000 cubic feet per second, and in 1931 to 70,000 cubic feet per second. These are less than the usual annual freshet flows. In fact, the 1931 flow is less than any during the period of record, with the exception of that in 1915. One result of the moderate floods was that the provisions for handling high flows were not taxed to anything approaching their capacity, thus favouring progress in construction. Furthermore, mild weather promoted progress also in both winters during which the work was being carried on.

Only one incident of importance occurred which had a retarding effect on the work. When the water had been lowered about nine feet on the power house site, a short section of the tailrace cofferdam failed by sliding. The cribs which moved were strengthened in their new position by steel sheet piling and additional fill, after which no further difficulty was experienced in dewatering the area. Subsequently, one 4-inch pump sufficed to handle all leakage through the cofferdam, which was about 1,200 feet in ength.

Preparatory work, preliminary to construction, commenced in October, 1929, and two years later four units were in operation, and four more by September, 1932, a very satisfactory result for so large a development.

These favourable results, of course, were not due solely to advantageous conditions of river flow and weather. The close co-operation of the participating corporations and of the members of the Executive and Engineering Boards, the loyal and effective work of the engineering staff, and the efficient and aggressive contractor's organization, all played their part.

PERSONNEL

The contractors were Messrs. Morrow and Beatty, of Peterborough, the principals of which firm, H. A. Morrow, M.E.I.C., and the late J. A. Beatty, M.E.I.C., were actively connected with the work, and were assisted by James Dick, A.M.E.I.C., as engineer and Mr. J. Barrett, general superintendent. The writer would like to take this opportunity of expressing his appreciation of the late Mr. Beatty, who played such a large part in the construction of the development, and whose high ethical standards, excellent judgment and charming personality contributed so largely to the excellent relations that existed at all times between contractors and principals. His death on March 28th, 1932, removed one who merited and received the respect and high regard of all who knew him.

Reference was made above to the constitution of the Executive and Engineering Boards. The members of the Executive Board were Dr. F. A. Gaby, M.E.I.C., chairman, and Mr. H. E. Guilfoyle, representing the Hydro-Electric Power Commission of Ontario, and Colonel C. W. Allen and J. B. Woodyatt, M.E.I.C., representing the Ottawa Valley Power Company. F. A. Robertson, A.M.E.I.C., acted as secretary to the Board. The writer of this paper was chairman of the Engineering Board, on which he and E. T. J. Brandon, A.M.E.I.C., represented the Commission, and J. S. H. Wurtele, M.E.I.C , and D. Stairs, M.E.I.C., represented the company.

On Otto Holden, A.M.E.I.C., as co-ordinating engineer, fell the duty of seeing that the directions of the Engineering Board were carried out. Mr. Holden, as assistant hydraulic engineer of the Commission, was also in charge of hydraulic engineering and design; while the electrical engineering and design was supervised by Mr. E. T. J. Brandon, chief electrical engineer, with Mr. A. H. Hull as his principal assistant. Colonel H. L. Trotter, M.E.I.C., was resident engineer.

Ontario Paper Steam Transformer Station at Thorold

By F. H. Chandler, A. N. Hunter and S. L. Fear, Electrical Engineering Dept., H.E.P.C. of Ont.

THE Hydro-Electric Power Commission has recently completed the installation of a 90,000 kw. electric steam generating station at the Ontario Paper Company's pulp and paper plant at Thorold, surplus electric energy being used to develop the Company's total steam demand at a pressure of 200 pounds per square inch gauge. The steam from this station replaces steam previously supplied from coal-fired boilers which consumed approximately 70,000 tons of foreign coal each year.

The three steam generators were connected to the Company's steam mains February 2nd, 1933, only four months' time being taken for the design of the station and purchase and installation of equipment. The official opening of the new plant took place March 10th, 1933.

Electrical Equipment

Lines

This station is supplied with electric energy over existing 110,000 volt lines from the Queenston plant, which are tapped close to the Company's property. A short single circuit line was erected from the tap to the station with disconnecting switches at the tap for emergency switching to the second line in case of trouble on the circuit being used for this customer.

Step-down Station

The electrical equipment consists of one bank of three 22,500 kv-a., outdoor type transformers (and one spare transformer of the same capacity) with 110 and 6.6 kv. outdoor bus equipment, three indoor 6.6 kv. indoor feeder equipments for controlling the electric steam generators and necessary steel structures, foundations and auxiliary service equipment.

High Voltage Outdoor Structure and Equipment

The high voltage outdoor structure consists of a galvanized steel structure (one girder and two towers), 45 feet high by 30 feet wide, for supporting the 110 kv. incoming line circuit and one end of the 110 kv. transformer bus, the other end of the bus being fastened to structural steel of the building. An electrically-operated ground disconnecting switch and a set of co-ordinating gaps are mounted on the top of this steel structure. The switch is closed by push button only and grounds one phase of the line. This ground causes the 110 kv. line oil breaker in Queenston Plant to open, cutting off this station in any emergency. Two push buttons are located at strategic points for this emergency. The set of co-ordinating gaps are to provide protection to the high voltage equipment from lightning. The 110 kv. electrical equipment for connecting the spare transformer and for grounding the 110 kv. line for maintenance work are mounted on the roof of the Company's building.

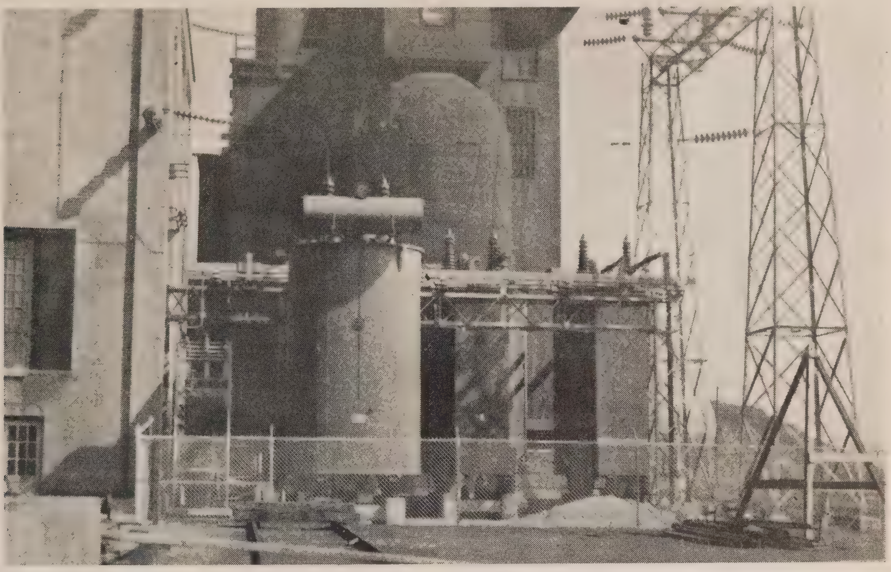


Fig. 1—Outdoor transformer station viewed from the south, sulphide plant shown in background.

The four transformers, installed in this station, are rated at 22,500 kv-a., single phase, 25 cycle, 69850/6600 volts (no taps), oil-insulated, water-cooled, outdoor type, designed for 55 deg. Cen. temperature rise. Remote temperature indicating equipment is mounted in the steam generator room on the control board.

Low Voltage Structure and Equipment

The low voltage outdoor structure consisting of one horizontal girder with one end supported on a steel tower and the other end fastened to the Company's building supports the outdoor section of the 6.6 kv. main bus with the 6.6 kv. metering current transformers and the leads to the power transformer. The indoor section of the 6.6 kv. bus and the electric steam generator leads are supported on both pipe and steel structures.

The 6.6 kv. main bus, carrying approximately 6,000 amperes at full load, consists of two 7-inch aluminum channel bars per phase (in box construction) and the connections from this bus to the power transformers and the electric steam generators consist of four 4 by ¼ in. copper bars per phase, special soldered aluminum to copper connectors being used for connecting same to main bus. Special busses consisting of two 4 by ¼ in. copper bars per phase were installed on the heads of each of the electric steam generators for making connections to the six electrodes. Supporting brackets were welded to the head. Heavy duty petticoat insulators are used to support the main 6.6 kv. bus and the connections to the transformers and electric steam generators and heavy duty corrugated insulators to support the smaller capacity busses on the electric steam generator covers.

Each indoor electric steam generator feeder is equipped with three 6.6 kv., 3,000 ampere S.P.S.T. high pressure contact disconnecting switches and one 6.6 kv., 3,000 ampere, 3 P.S.T. motor-operated automatic oil circuit breaker.

Relay System

The relay protection is designed to give instantaneous clearance of any faults in the 6.6 kv. system. It consists of,—

1. Distance type protection on each generator feeder to give selective clearance in case of a ground or short-circuit on the feeder or generator.
2. A differential for grounds on the 6.6 kv. bus to open the steam generator feeder breakers, as the steam generators are the source of the ground currents.
3. A residual voltage ground detector to clear the steam generator feeder breakers after a time delay and give an alarm in case of a light ground.

Other Protections

(1) Failure of the circulating pump circuits opens the breaker on the generator on which the trouble occurs.

(2) Protection of the transformer bank is by the line relays at the generating station.

Service Equipment

The station service equipment consists of a bank of three 75 kv-a., 6600/550 volt, single phase, 25 cycle, oil-insulated, self-cooled, outdoor transformers equipped with three 6.6 kv. disconnecting switch type fuses. The 550 volt service equipment for

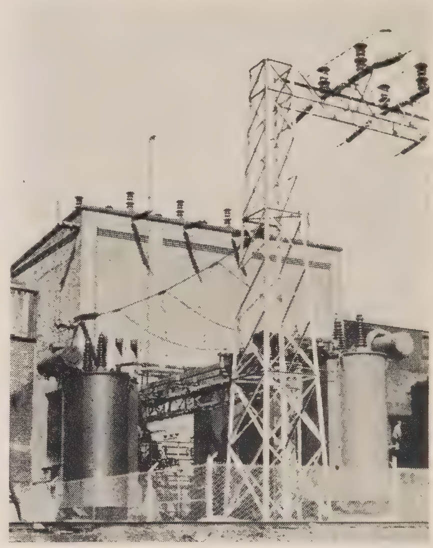


Fig. 2—Outdoor transformer station and steam generator building viewed from the South East, spare transformer at left.

the control of two 125 h.p., 550 volt, 3 phase feed water pumps, three 30 h.p., 550 volt, 3 phase circulating water pumps and one bank of three 3 kv-a., 550/110 volt service transformers is fed from this bank.

The bank of 3 kv-a., transformers is connected to supply the 110 volt, 3 phase service for the electric closing of the 6.6 kv. oil breakers, the outdoor lighting system, and the trickle charger for charging the 12 cell, 60 ampere-hour storage battery which supplies the 24 volt d.c. service for tripping the oil breakers and energizing the indicating lamps.

Mechanical

Steam Generators

The three electric steam generators are each rated at 30,000 kilowatts (approximately 90,000 pounds of steam per hour). Each generator is a

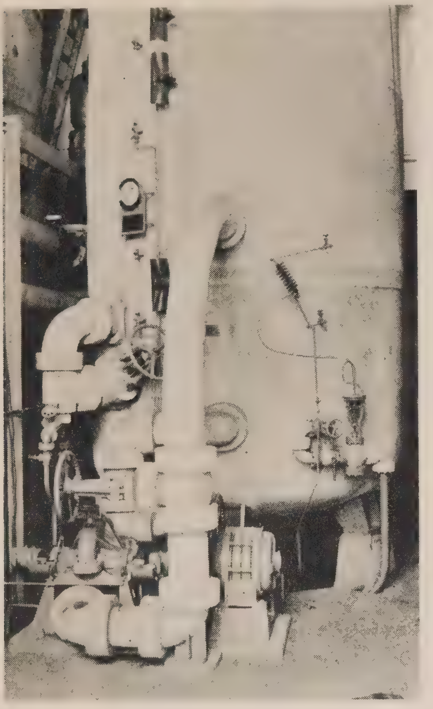


Fig. 3—No. 2 electric steam generator viewed from the main door, showing circulating pump, basket drain to the left and automatic feed water regulator at the right, main control valve shown on discharge side of pump piping.

vertical cylindrical tank 11 ft., 6 in., in diameter and 25 ft. high designed for 200 pounds pressure. The shell thickness is 1⅜ in. and the head thickness 2-7/16 in.

Each generator consists of two main chambers. The lower part of the tank provides approximately 9 ft. of water storage. The upper portion provides steam space and in this portion a conical bottom, open top cylindrical tank or basket is supported so that the vertical electrodes hang from the shell top head down into the basket.

The water in the generators is continuously circulated. It is drawn from the storage portion and delivered to the basket by a centrifugal pump and piping; part is evaporated into steam in the basket, and the balance returns from the basket to the storage by an external pipe connection. A valve in the pump discharge regulates the quantity of water delivered to the basket, the water level in the basket, and, therefore, the amount of electrode immersion or the rate of steaming. A valve is provided in the drain from the basket to regulate the amount of water drained as may be required by operating conditions. Two other connections are made to the drain—one for periodic blow-off, the other for continuously bleeding off from the basket water which has become concentrated by evaporation in the electrode chamber.

Six hollow triangular shaped cast iron electrodes, approximately four feet long, are rigidly supported and insulated from the top head. The current carrying copper rods enter the tank through specially designed porcelain insulating bushings.

Since the basket shell is not required to hold pressure, its construction is of thinner plate than the tank. The basket shell forms one path of the current and any pitting which may develop occurs on the basket and not on the tank. Any pitted sections of the basket shell may be removed and new sections welded in, without affecting the pressure vessel.

The generation of steam in electric steam generators is obtained by the passage of the electric current through the water from electrode to electrode

and basket. The resistance of the water used is of prime importance, and a knowledge of the resistance of natural water available, which may be used as "make up", and of "condensate" from the mill process, is required for design purposes. The resistance of natural waters may be low and require the addition of a considerable quantity of higher resistance condensate to obtain a feed water suitable for use in the generators at the desired operating voltage. Due to the evaporation of the water in the basket, the concentration of solids increases and necessitates removal of the concentrates by continuously bleeding from the basket drain. The "bleed" water is removed from the generator so that the water in the electrode chamber will have a resistance suitable for an immersion of the electrodes which will give a reasonable current density on the electrodes for full load steam generation. The heat in the "bleed" water may be reclaimed by the use of a heat exchanger in the feed water supply.

The arrangement of six electrodes—two per phase, in a single tank is believed to be conducive to good electrical balance between phases. No difficulty in operation due to unbalance has occurred during three months' operation. Considerable care was taken to have all electrodes vertical and exactly spaced.

The minimum steam output from each generator is approximately 18,000 pounds of steam per hour which requires an electrical input of 6,000 kw. and an electrode immersion of 6 inches. Lower steaming rates are not possible due to the unstable electrical operation with less than 6 inches immersion. The formation of hydrogen and oxygen is negligible when the current density is kept sufficiently low.

Separators

Each generator is provided with a steam separator to assure a steam quality of 99 per cent. dry at the separator outlet. A stop valve is inserted between the generator and the separator and an automatic stop check valve in each 10 inch generator steam branch to the header.

Feed Water Pump

The feed water is supplied to the generators by a four stage centrifugal pump designed for 500 gallons per minute against 580 ft. head. At the delivery to each generator, a feed water regulator is provided to maintain a constant level of water in the low portion of the generator tank. A duplicate feed pump has been provided by the Company.

Expansion Joints

Since the steam branches from each generator had to be arranged in line with the header because of the space limitations for the generators, expansion was provided for by the use of two copper expansion joints—one each side of the steam main centre branch tee.

Drains

Each separator and each stop check valve is provided with a valved pipe drain connected to separate drain headers supported below the main steam header. The drain headers are connected to a continuously draining trap which discharges the water to a flash tank. This arrangement of

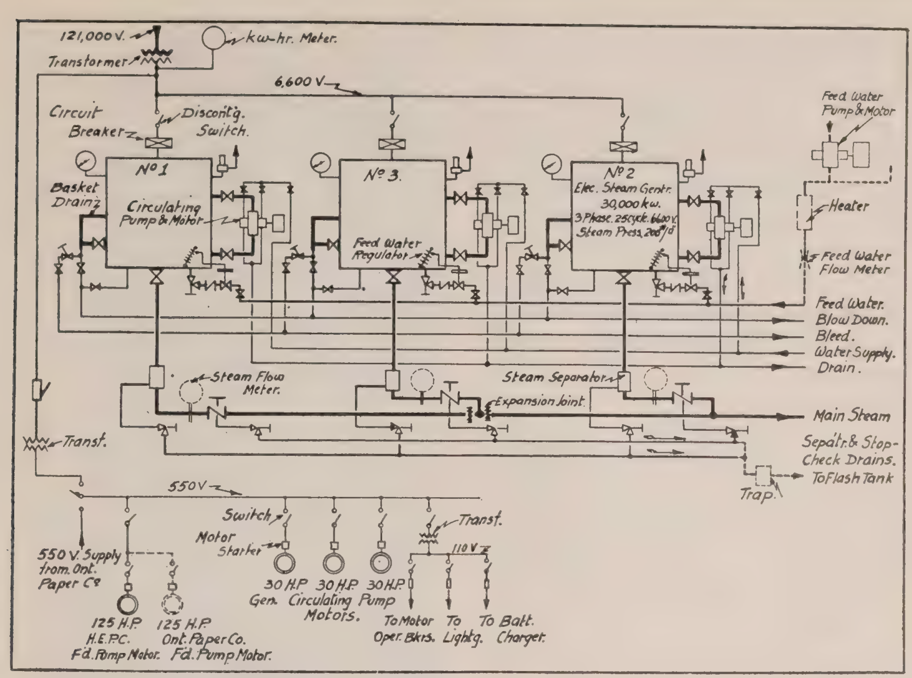


Fig. 4—Diagram of electrical and piping connections.

drains provides thorough drainage of the steam piping at all times and, therefore, the elimination of water hammer.

The generators were built to the Canadian Inter-Provincial Regulation and each generator was equipped with four high capacity safety valves complete with vertical discharge pipes through the roof and drain pipes for condensed steam.

Recording Instruments

The Commission has provided a totalizing kilowatt-hour meter and graphic wattmeter for measuring the electrical input to the three generators on the 6,600 volt bus.

The Company has provided the following steam and water meters for measuring the steam generated output,—

Steam Flow—Orifice type recording flow meter for each generator.

Feed Water—Venturi recording meter for all generators.

Make-up Water—Orifice type recording meter for all generators.

Bleed Water—Orifice type recording meter for all generators discharging to drain.

Insulation

The steam generators and steam piping were insulated with air insulating material which has a strong bonding characteristic to hot metal, can be quickly applied and easily removed and replaced in case of leakage.

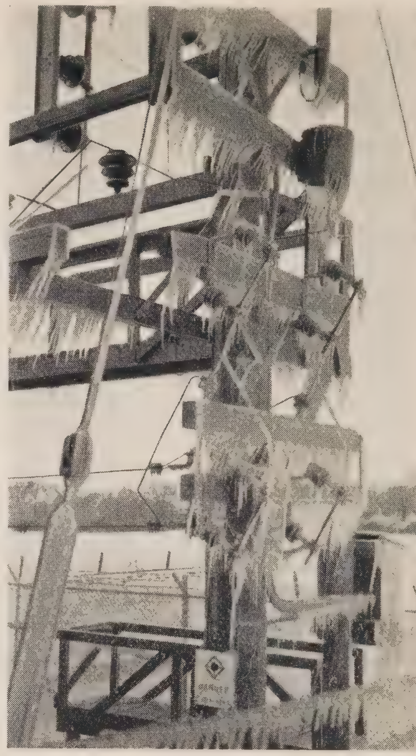
The design of the station and installation of the electric steam generators and connecting electrical

equipment were made by the Commission. The design and construction of the enclosing building were made by the Ontario Paper Company. Close co-operation between the engineers of the two organizations existed and proved very effective in facilitating progress of the work.

The single line diagram fig. 4 indicates the electrical connections to and the piping connections from the steam generators.

APPENDIX

Power Transformers—The Canadian General Electric Co. Ltd.
6.6 kv. Oil Circuit Breakers—The English Electric Co. of Canada Ltd.
Service Transformers—Ferranti Electric Ltd.
Meters and Relays—Canadian Westinghouse Co. Ltd.
Disconnecting Switches and Insulator Conductor Fittings—Eastern Power Devices Ltd.
Aluminum Bus—Aluminum Co. of Canada Ltd.
Copper Connections—Anaconda American Brass Ltd.
Relays—Cansfield Electrical Works Ltd.
Battery—Hart Battery Co., Ltd.
Insulators—Canadian Porcelain Co. Ltd.
Steel Structures—Canadian Bridge Co. Ltd.
Steel Structures—Standard Steel Construction Co. Ltd.
Steam Generators—Canadian General Electric Co.
Feed Water Pump—Canadian Allis-Chalmers Co.
Pipe—Page-Hersey Co.
Insulation—Affiliated Engineering Co.



Consecon substation after a sleet storm. There was no trouble of any kind.

O.M.E.A - A.M.E.U.
Summer Convention
at Windsor, Ont.
June 22, 23 and 24, 1933

Public Works Which Are Justified in the Present Crisis

SUCH is the title of a pamphlet issued by the Northern Electric Company, Limited, during February. The pamphlet gives some facts and figures based on data prepared and compiled by this company in respect to underground conduit work. The compiling of these data was inspired by an article of Sir Josiah Stamp, a Director of the Bank of England, published in BARRON'S WEEKLY, November 21, 1932. What follows has been extracted from the Northern Electric Company bulletin.

* * * *

WISE SPENDING AND WISE SAVING

Hoarding Means Deflation and Unemployment — Consumption Should Be Stimulated

(*Considerable controversy has been aroused by a letter in the London* Times, *signed by six leading British economists, including Sir Josiah Stamp, advocating free spending, by individuals and by public authorities, as essential to minimize unemployment. In view of the importance of this subject we have obtained this special article by Sir Josiah, in which his views are elaborated.*)

By SIR JOSIAH STAMP, G.C.B., D.Sc.

There are certain special aspects of the question whether free general spending is desirable which come at once to the mind. They are not, of course, forgotten, but when you examine them you will find that these special aspects emphasize rather than qualify the importance of that principle. They serve to show that, at particular points, other questions of public policy may be paramount and the argument for spending overlaid by stronger ones.

First, with regard to savings by working classes, and so on, it is essential that the flow of mass savings should be maintained unimpaired. These savings cannot be made to fluctuate with the necessary inflows according to the capital-investment market's needs. You cannot blow hot and cold when you are trying to create a habit, and the social habits involved in thrift are, in the long run, of supreme importance. This point is particularly imperative at the present moment, when the money receipts of those who succeed in remaining in employment have, owing to the low level of prices, the highest purchasing power in history. Now it is very desirable that this special spending capacity should not be too quickly hardened into the custom of day-to-day spending, otherwise, when the price level rises, it might be regarded as affecting the day-to-day standard of life. So this kind of saving ought to go on uninterruptedly.

In the second place, the credit of public bodies varies and some may be unable to add capital expenditure to their existing commitments without either harming that credit unduly for the future or throwing a greater charge on the rates, which will impair the spending rather than the saving power of the ratepayers. Reservations like these throw all the more

responsibility upon us, for the application of the broad principles of non-hoarding over the wide field of purchasing power in which no counter body of considerations prevail, and in which the operation of the principle is entirely valid. Whenever such applications are possible, therefore, spending wisely but without stint is desirable.

The Use of Purchasing Power

The root fallacy in most people's thinking on this problem is the idea that purchasing power can be put into a cupboard over a period of time and taken out again at some future date, whereas, although this may seem to be possible for the individual, for the community as a whole it is impossible. If a man produces more than he consumes, and puts the remainder of his purchasing power in a cupboard, he is hoarding and deflating. If he puts it into a bank and the bank is unable fully to use it in business, it is also hoarded, and deflation results.

The reason why what is true for one person is not necessarily true for the community is that a man can successfully refrain, as when he puts his money in the bank, only from consuming the current production to which he is entitled over and above his present consumption, without deflation, provided someone else in the community does the reverse process by consuming more than he produces, that is, he borrows the excess and unused purchasing power of the first individual. And if the whole community tries to refrain from spending at one time, then unemployment is bound to result, because there is a surplus of purchasing power that is unused. Purchasing power cannot be stored up over periods of time; it can only be transferred. What looks like "saving" is then really only deflation, succeeded by reflation when the purchasing power is exercised.

The question whether public bodies ought, at a particular moment, to engage in expenditure is related to their own credit and what would be done with the purchasing power if they left it in the hands of their ratepayers. At the present time, many public authorities, while still taking purchasing power away from their contributors, are no longer spending it themselves, but are trying to save and improve their position by paying off bank advances. This is happening on a wide scale, and, however gratifying to the authorities in question, is simply suicidal in its consequences from the national standpoint. If taxes and rates are reduced *pro tanto*, and if the beneficiaries of the reduction will spend the money instead of hoarding it, then the results will be really good. But it must be left open for nice judgment at any particular time whether the principle of economy is not being carried to an excess in sterilizing or in annihilating purchasing power.

Needed—A Return of Confidence

I am also asked how general spending can be reconciled with the provision of the capital required by industry. The fact is that industry is not at present drawing on the savings that have been accumulated. Obviously, a revival of confidence, and freedom from restrictions, enabling new enterprise to pick up the

savings and use them, is the one straight way out of the difficulty. So long as someone in the community is spending for capital purposes, saving is a virtue—otherwise it is a delusion. I have no desire, of course, permanently to see the purchasing power of the community used for ephemeral purposes, but, either in their own hands or of their collective public authorities, it should also be used for permanent capital goods. The public authorities appear unconvinced of the desirability of using their resources and their credit in creating a demand for capital goods. Business cannot be expected to embark on outlays requiring new capital until there are reasonable prospects of that capital being remuneratively employable, and the more purchasing power is hoarded the less chance is there of a reasonable return being earned upon industrial capital.

Between cautious business, and cautious public authorities, the total savings are no longer being used, and they cannot *last*, they have no enduring power, they melt away into deflation and increased unemployment. So long as permanent capital goods are not being demanded either by business or by public authorities, then, in the name of stability, we must buy the current output of consumable goods and stimulate consumption by all means possible. The ideal is a balance between spending on consumable goods and saving and capital expenditure. But saving and capital expenditure go together, and if they are divorced, then general spending is the next best expedient.

* * * *

Then again in the Report of The Unemployment Research Committee of Ontario 1929-1932, page 280, the finding of this committee in regard to public works as a relief measure is as follows:

Public Works: Relief works of the sort that have been carried on in Ontario during the past two years are no longer practicable or desirable. Neither the carrying out of unnecessary work to provide employment nor of necessary work by inefficient methods has been sound. However, the broad principle of giving the unemployed work rather than a dole is thoroughly sound, providing it is applied in the right way. So far as governmental bodies are concerned, those that are financially in good condition, that can borrow without too great difficulty, and that have necessary works waiting to be done, should expand, rather than contract their construction activities. In so doing they pump credit into a badly deflated financial system and stimulate all sections of it. The projects should not be organized primarily on a relief basis but should be carried on as efficiently and economically as possible, with workers who may be very much in need but who would be chosen not so much for this as for their competence for the job in hand. While there can only be limited application of a policy of this kind under present circumstances, it ought to be pursued wherever possible, with the plan in mind of curtailing public construction expenditures when private business activity revives and takes up the present slack in employment.

* * * *

"Yardsticks" for Public Works Expenditure

Any public work project must satisfactorily stand investigation from different angles, namely:

1. Does it provide a maximum use of labor, with as wide a diversification as possible in the classes of labor used when compared with other classes of public works?
2. Will it be of benefit to a reasonable percentage of the community in which it is placed, or in other words, will it be a useful public utility?
3. Is it a new and untried project, or is it an extension of an existing undertaking such as water main, sewer, underground conduit, paving, etc.?
4. Will it be revenue producing, *i.e.*, self-supporting, either wholly or in part?
5. Will it create or cause further employment?

* * * *

Underground Electrical Services Not an Experiment

The advantages arising out of a conduit construction programme have been well set up in a report issued by the Electrical Commission for the City of Montreal, in 1930, summarized as follows:

1. The work of the Fire Department in erecting their apparatus is facilitated and made less hazardous. A slight reduction in insurance rates on this account is often effected after poles and wires have been removed. The interruption of electrical service on a pole line passing burning buildings is avoided.
2. The improved appearance of the streets from which poles have been removed speaks for itself.
3. A thoroughly modern and flexible street lighting system.
4. Up-to-date fire alarm and police signal systems.
5. City pumping stations being gradually inter-connected underground electrically, to ensure greater reliability.
6. Further damage to trees by overhead wires avoided.
7. All electrical services rendered immune from wind, lightning or sleet storms in the underground area.
8. Elimination of danger to public from falling wires, poles, etc.
9. All kinds of electrical services improved in quality on account of the change over from an old overhead system built up in a piecemeal manner to a new underground system carefully designed for existing and future requirements.
10. Greatly enlarged capacity to take care of changing requirements without unnecessary cutting up of streets or the erection of more unsightly poles. Witness the enormous development now taking place in the central portion of the City of Montreal with practically no street cutting required except for the occasional change in service location of a new building.

* * * *

Discussing the Construction of Conduits from the Viewpoints Suggested

1. Does it provide a maximum use of labor, with as wide a diversification as possible in the classes

of labor used when compared with other classes of public works?

An example and an analysis of a recent job is most convincing, and while it is possible to gather complete data on a number of jobs, this can be taken as a fair representation of this class of work. On larger or smaller jobs the percentage of wages to the total cost would naturally vary to some extent, but under every condition the percentage of wages to the total cost will always be an important factor.

ANALYSIS OF LABOR EMPLOYED

(*A*) *Direct Labor.*

Pick and shovel type..........Man days 9,900

Skilled and semi-skilled (includes teamsters and truck drivers)..Man days 2,777

Supervision and office.........Man days 1,816

Total man days direct labor................ 14,493

(*B*) *Indirect Labor.* (*Manufacturing Materials*).

Skilled, semi-skilled and common labor.........Man days 3,124

Supervision and office.........Man days 544

Total man days indirect labor................ 3,668

TOTAL MAN DAYS EMPLOYMENT GIVEN........................18,161

APPROXIMATE PERCENTAGE OF WAGES COMPARED TO THE COST OF THE JOB..54.9%

GENERAL INFORMATION

Approximate cost of job, including repairing of sidewalks, paving, office, engineering and overhead................ $125,000.00

No mechanical shovels or excavators used; horse-drawn vehicles used in the cartage of surplus of excavation; transit mixed concrete used; hours of labor—8 per day.

Excavation removed to dump..............	8,000 tons
Concrete used........	3,500 cu. yds.
2,660 tons sand; 3,400 tons of stone; 760 tons of cement.	
Steel work............	8 tons
Castings.............	38 tons
Fibre conduit.........	260,000 feet

NOTE PARTICULARLY in the analysis of labor the diversification of labor employed. Supervision and office covers the so-called "white collar" wage earner and includes—engineers, draftsmen, office and time clerks, and superintendents. In the skilled labor class are included carpenters, masons, cement workers, foundry men, quarrymen, machine tenders, etc., whilst common labor, which is a large percentage in underground conduit construction, covers pick and shovel men, drivers and a percentage of semi-skilled type of workers.

2. Public utility use—will it be of benefit to a reasonable percentage of the community in which it is placed—or in other words, a useful public utility?

   Underground conduits house and protect all the electrical systems of power, lighting, and communication. They are, therefore, of service to the entire community. Inherently, they are in general confined to the central portions of towns and cities.

3. Is it a new and untried project, or is it an extension of an existing undertaking such as water mains, sewers, underground conduits, paving, etc.?

Conduits are a public utility which perform a service to the public the same as a sewerage system, gas and water mains, etc.

4. Will it be revenue-producing, *i.e.*, self-supporting?

Yes: It is a part of a revenue-producing utility, and is not a charge on general taxation.

5. Will it create or cause further employment?

Yes: and to a larger degree than most other types of public works. The completion of underground conduits on a street is followed by the installation of cables, lamp standards and other equipment, also by a certain amount of rearranging of service wiring inside and outside of buildings in order to change the overhead to underground service. In the particular job analysed there will be some 350 small wiring jobs required. Some further employment is afforded in the removal and salvage of the poles and overhead wires.

The Cost of Neglected Maintenance

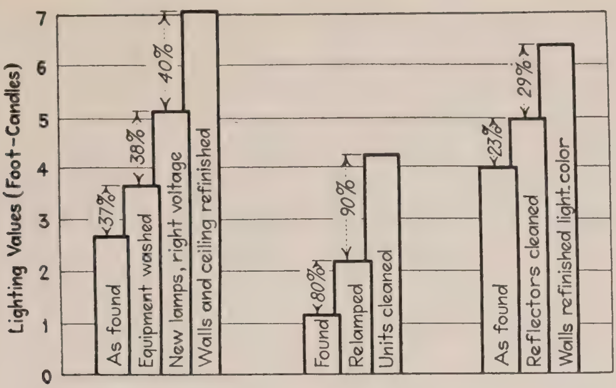
By Samuel G. Hibben, Westinghouse Lamp Company, Bloomfield, N.J.

(*From a paper presented at a Conference on Economics of Applied Lighting, at Cleveland, Ohio.*)

WHEN illumination is purchased, the buyer should rate his purchase on the basis of sustained "seeing ability" per dollar spent. The cost per kilowatt-hour for electric power is a prime factor only when one knows how efficiently this power is translated into light. The cost of the lamp bulb is a factor only when we know how much and what quality of radiation it emits. The worth of reflectors and accessories is indeterminant until we know just how they redirect and continue to redirect the light to the work. Even so, we must yet reckon with the light that may efficiently come from the lighting unit, but be lost through absorption in surrounding objects or surfaces before it can reach the work under observation.

To a large degree our final criterion, "Seeing Ability", depends upon the co-ordinated efficiencies of all such factors. If the efficiency of anyone of them is low or is allowed to fall off, then such a weak link weakens the chain and nullifies the good work of the neighboring components.

It is not with the general subject of initial efficiencies nor primarily of installation or power costs that we are concerned in this particular consideration. The things I would commend to your attention are the losses through the neglect of the lighting installation, i.e., the *high cost of low maintenance.* Take council upon how to guard against the insidious losses



Results obtained from proper lighting maintenance.

resulting from such items as low voltage, improper or aged lamps, dusty reflectors, dirty walls and ceiling surfaces, empty sockets,—*poor housekeeping!*

I would say that if all our lighting installations and their immediate surroundings could be cleaned and reconditioned to-day, then the illumination that this nation would receive tonight would be well-nigh twice the amount that it enjoyed last night!

Where maintenance is poor and lighting systems depreciate, the losses due to neglect may be roughly classified as follows:

1. Dirty lamps and accessories.
2. Darkened or discolored walls and ceilings.
3. Lamp bulbs of poor quality or low efficiency.
4. Empty sockets and unobserved burnouts.
5. Aged lamps past their prime of usefulness.
6. Under-voltage burning of lamps.
7. Improper combination of lamp and reflector.

Dirty Equipment

Consider first the advantages and costs of keeping the lighting equipment clean. I have repeatedly stated that "water is cheaper than watts", but in spite of that fact, we would be appalled if we knew how seldom on the average lamps and reflectors are properly washed. Of all our public or private servants, Caucasian or Ethiopian, the most conspicuous by their absence are the Gold-Dust Twins,—yet washing is vital to our net objective, *seeing ability!*

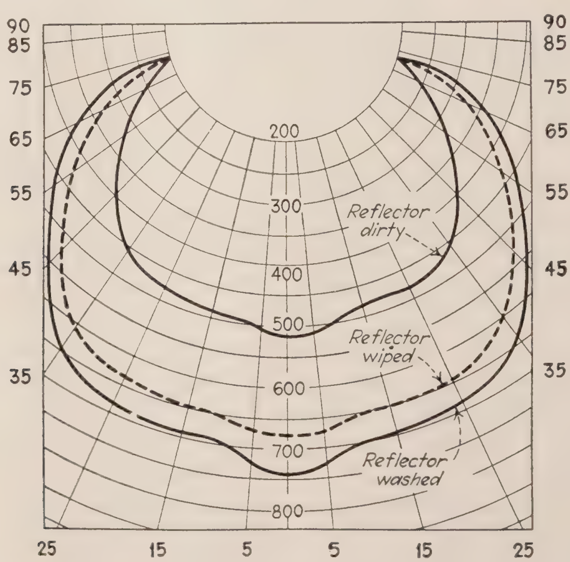
Many common-place examples exist to demonstrate the importance of removing films of dust and grease from the lighting units. I recall, for example, the case of a glassteel diffuser in a somewhat smoky machine shop, that when new produced over 12 foot-candles of illumination on the work-bench beneath. It had so gradually gotten dirty after weeks of neglect that less than 3-foot candles finally resulted, meaning that the cost of light on the work had quadrupled. It meant that out of every dollar spent for electric power and lamp bulbs, 75 cents was being wasted.

During the investigation of a certain large office building where the lighting units consisted of semi-indirect bowls that appeared from the floor to be perfectly clean, I measured the average room illumination, then removed the glass bowl and washed it thoroughly, replaced it and found that the foot-candles were increased from 1.8 to 2.4, or 33 per cent.

A third not uncommon example may be taken from a building in this city. The totally indirect lighting system after some two years of operation was the subject of dissatisfaction. Some 3.75 foot-candles were measured on the desk tops. First, the reflectors were thoroughly cleaned. The foot-candles were increased to 4.68 or a gain of 25 per cent. Since the lamp bulbs were visibly aged and dirty, new lamps were installed and the foot-candles moved up to 5.26, or a gain of 40 per cent.

The ceiling was repainted from a yellowish cream to a lighter tint and the foot-candles grew to 6.78 or a total gain of 81 per cent. Examples of this sort multiply indefinitely.

Of course one must expect a continuous depreciation due to the continuing deposits of dust on reflectors and the continual aging of lamps. However, this falling off in efficiency is not a straight line function. Usually the greatest losses occur in the first month or six weeks. (Some 15 per cent. in the first month is perhaps a fair average). Dust deposited upon old dust is not so costly as is the first thin layer. The loss of light from the normal and unavoidable depreciation of the lamp bulb itself from internal blackening seldom brings the final output of that lamp below 90 per cent. of its initial efficiency. However, blackening does continue as almost a straight line slope and hence a very aged lamp bulb can economically be removed and replaced by a new one



Effect of dirty reflectors very marked.

should it be found to live much beyond its rated life.

Cleaning Costs

In any discussion of economics one naturally asks the question, "how should lighting equipment be cleaned and what does it cost?" In general the experience of past years has shown that bulbs and reflectors should be wiped free of dust at least once each month. Except in unusually dirty locations they should be washed at least once every 60 days. It is not a bad plan to alternate dry and wet cleaning. In a typical office building the average janitor can remove the glassware from an overhead fixture, scrub, dry and replace it, in from 4 to 5 minutes. Under such circumstances I have collected data in two large buildings showing that the complete cost of cleaning maintenance per visit varied roughly from 5cents to 15cents.

Looking at the problem in another way, consider the office building where the annual electric power costs were some $8,770. The cost of lamp bulbs and the insertion thereof was about $1,035 while the annual total cost of lighting equipment maintenance (including breakage) and supervision was some $4,600.

Stubborn cases of encrusted, greasy dirt require warm water and soap or a mild grease solvent. Extreme cases of hardened sooty deposits particularly on surfaces outdoors may require a dilute solution of oxalic or similar acid. After the common washing with soapy water and to avoid the soap film that will hold the next deposit of dust, wipe and dry the reflector carefully or preferably rinse in ammonia water.

Cleaning costs vary, but taken alone they seem to average in the neighborhood of 4 per cent. of the total operating costs of a lighting installation. If, as seems evident, such cleaning will in itself increase the illumination 20 or 25 per cent., then the results pay for the expenditure 4 or 5 times.

The accessibility of the lighting unit (and of the lamp) is very important. In commercial installations, if the bulb can be removed without taking down the globe, the maintenance is simplified materially. In industrial installations, the "safe-change hanger" or disconnecting plug facilitates removal of both reflector and lamp to the floor for easy washing. Just what this means in economy is illustrated by the following study.

To clean 5,700 Glassteel lighting units, in their regular overhead position, at eight minutes each, requires 45,600 minutes, or 760 hours to clean. (Labor for this operation costs 62 cents per hour). Therefore, the cost of each complete plant wash $= 760 \times 0.62 = \$471.20$. Considering four washes per year, the yearly cost $= 4 \times 471.20 = \$1,884.80$. With a cleaning time per unit of two and one-half minutes, made possible by a removable hanger, it takes 14,250 minutes, or 237½ hours to clean the 5,700 Glassteels. With labor at 62 cents per hour, the cost for one complete plant wash is $147.25. The yearly cost or the cost of four complete washes = $589.00. Thus the installation of Safe Change Hangers effected a saving of $1,295.80 per year, or 68 per cent. of the yearly cost of keeping lights clean and efficient.

Dirty Interior Surfaces

What we have discussed about dirt on the reflector applies in principle to grimy or discolored interior surfaces. Neglecting for a moment the efficiency differences of different colors of painted surfaces, we may consider merely the losses due to neglect thereof. In an enclosed space under ideal conditions for internal reflections, the theoretical change in illumination is represented by the formula $\frac{1}{1-K}$ where K is the coefficient of reflection. Thus theoretically if the reflection coefficient of the interior is doubled, the illumination is increased between three and four-fold.

Individual studies must be made to ascertain how frequently an interior may be repainted, but it seems common practice to find it economical to wash most painted interiors once annually. How much the reflection coefficient may be increased by washing is impossible to answer definitely but many studies indicate that an increase on the order of 10 per cent. is not uncommon.

Washing interior surfaces is an art. One good method is to thoroughly dampen a rather large area with clean water, preferably sprayed on, and never apply a washing solution or the cleaning sponge directly on a dry surface. One suggested method is of interest, namely, to coat the freshly painted surface with a thin water-soluble material such as colorless starch. When after some considerable period this surface become dirty it may be easily dissolved away, leaving the painted surface in its original condition, since the dirt comes away with the starch.

The Inoperative Socket

Empty sockets and unobserved burnouts take their toll of lighting efficiency. Fixed charges, as cost of installation and investment, continue whether the socket is empty or full.

Obviously the unobserved burnout is doubly to be avoided because if the unit appears ready for service and yet fails to function in an emergency or need, it represents a definite loss,—sometimes an accident hazard. If an installation of a plurality of sockets can be found satisfactory, when a considerable number of the lamps are burned out or removed, then the *prima facia* evidence is that the lighting plan was at fault. Surplus dead sockets cost something as stand-by investments and one would conclude that the most economical installation should have been based upon the minimum number of sockets but each lamped and doing its full share of duty.

Undervoltage

Another pocketbook problem in connection with the economics of maintenance is the under-voltage burning of the lamp. The general features of wiring and voltage have been discussed previously but under our present consideration comes the matter of voltage as effected strictly by maintenance. To a minor degree, there may be some loss in voltage due to any corroded contacts throughout the system. To a greater degree, there is a voltage loss resulting from haphazardly extending or overloading branch circuits,—a temptation that exists through practicing the false economy of saving a little copper at the cost of lumens. A recognized and

inevitable voltage drop in even a good system is 2.5 volts. In the main this is counter-balanced by providing a slightly excess voltage at the service entrance or the distribution panel. The cost evaluated in units of light amounts to approximately a 3 per cent. diminution of illumination for a 1 per cent. drop in voltage. Consequently the highest economy dictates that there must be the closest possible agreement between the designed and rated voltage of the lamp and the actual socket voltage, or that the latter be not less than the former. By over-voltage burning, one gains light at the cost of life, but as lamp bulbs have been and are in general constantly decreasing in first cost, this feature of operating costs deserves much careful study.

The Combination of Lamp and Accessory

Finally, in our endeavor to strengthen each link, and to secure the most seeing ability for our dollar, we must direct our generated light to its point of usefulness. If the glass reflector be broken, the light is wasted sidewise since the proper reflector usually increases the usable light from 2 to 3 times over that from the bare lamp. If the metal reflector becomes tarnished or bent much the same thing occurs. If,—and this is an important point,—the wrong size of lamp bulb be inserted in the reflector, then the emitted beam is changed and the combination looses effectiveness. For example, a 200 watt size of RLM reflector and a corresponding wattage of lamp will emit light with an output efficiency of about 70 per cent. If a 150 watt lamp be inserted in this same reflector the output efficiency drops to about 62 per cent. One of the best checks on this loss is a study of the proper reflector holder or of the socket position therein, and to guard against the careless interchange of bulbs and accessories.

Finally, the whole secret of an efficient lighting installation after it has once been properly installed lies in *planned periodic attention.* Frequently illuminometer surveys are recommended in order to detect depreciation. Above all, the maintenance must be made the regular duty of a reliable employee who is given to appreciate the worth of his job. He should receive credit for doing a good job. Neglect that is quite common to-day has been proven to reduce the possible illumination by an estimated amount of easily 1/3. Reasonable maintenance seems to cost much less than the value of the light gained thereby. The total lighting bill of the United States last year was perhaps one billion dollars. Adequate and intelligent maintenance it it may save 1/3 of our lighting costs or may add a corresponding amount to our usable illumination, may therefore be worth $300,000,000.

E.I.C. Engineering Catalogue

The Engineering Institute of Canada is to be congratulated on its Engineering Catalogue, the first edition of which (1932-33) has been circulated recently. By issuing this publication the Engineering Institute of Canada is enlarging a service which it has been rendering for some years to its members and those engaged in industrial and other engineering works throughout Canada.

The frequent enquiries received in the past as to the sources of supply of engineering equipment, materials and supplies, the addresses of manufacturers and suppliers, and technical data descriptive of their products, have required the maintenance of extensive files from which to secure the required information. This material, with much additional matter, has now been incorporated in the Catalogue, which presents the necessary data in a readily accessible form. Thus, in undertaking the publication of this Catalogue, The Institute is definitely fulfilling one of its principal functions, the dissemination of technical information.

In the volume now published it will be found that the list of subject headings has been drawn up on a widely extended basis, with reference to all branches of engineering. It includes some 1,800 entries dealing with a variety of materials, equipment and products, ranging, for instance, from abrasive materials and bag-filling machinery to ventilating systems and zinc. Information as to their products has been furnished by some 2,400 individual firms.

The function of the Catalogue is:

(1) To furnish data relative to all classes of engineering equipment, materials and supplies used in industrial and engineering work which might guide the purchaser in making his choice of the product best suited to his requirements, and

(2) To provide conveniently arranged data giving the Canadian sources of supply of the various products.

The plan adopted in the compilation of the data is believed to offer the most convenient arrangement to serve the requirements of the Canadian purchaser.

The first, or Catalogue Section, contains products data; the pages descriptive of similar or related products being grouped together, as far as possible, although under existing conditions this has not been possible in every case.

In the second, or Index Section, the various subject headings of products are listed alphabetically with the names of the manufacturers in each case. From this, the sources of supply of any particular product can be secured.

This Index Section is supplemented by an Alphabetically arranged list of firms (the Directory Section), with complete addresses and other useful information.

This publication should make a very handy and useful office reference for all Canadian executives whose duties extend to the purchasing of plant and supplies as it gives a complete list of Canadian products and where they can be secured.

A nominal price of $15.00 has been placed on the catalogue.

Association of Municipal Electrical Utilities

Minutes of Executive Committee Meeting

A meeting of the Executive Committee of the Association of Municipal Electrical Utilities was held at the office of the Hydro-Electric Power Commission of Ontario on Tuesday, April 18th, 1933.

The meeting was opened at 2.30 p.m. by the Vice-President, W. R. Catton as Chairman. Other executive officers present were—Messrs. O. M. Perry, E. V. Buchanan, T. J. Hannigan, G. E. Chase, M. W. Rogers, R. S. King, C. E. Schwenger, O. H. Scott, R. S. Reynolds, D. J. McAuley and S. R. A. Clement; Messrs. D. B. McColl, G. F. Drewry and C. H. Hopper also attended in the interest of the Convention Committee.

It was moved by Mr. O. H. Scott and seconded by Mr. G. E. Chase "THAT the Minutes of Executive Committee meetings of September 8th, 1932 and January 24th, 1933, and of Convention of January 24th and 25th, 1933, which had been published in the BULLETIN be taken as read and adopted".—*Carried.*

This meeting was called for the purpose of arranging for the summer Convention to be held at the Prince Edward Hotel, Windsor, Ontario, on June 22nd, 23rd and 24th, 1933.

The Secretary advised of having had Mr. O. M. Perry make inquiries whether a stenographic reporter would be available at Windsor for the Convention so as to avoid the extra expense of bringing a reporter from Toronto.

Mrs. E. Cooper representing the Stenotype Reporting Bureau of the MacLean Publishing Company, Limited, Toronto, who had been reporting the Association Conventions in Toronto, addressed the meeting in the interests of her department, quoting rates. As Mr. Perry could not state definitely the rates the Windsor reporter would charge it was moved by Mr. E. V. Buchanan and seconded by Mr. M. W. Rogers "THAT the Vice-President, Secretary and Treasurer be a committee to arrange for reporting the Convention".—*Carried.*

The Secretary referred to the question of badges for the Convention asking if the tag form of badge should be continued or should the bar and ribbon type as formerly used be obtained.

It was moved by Mr. O. M. Perry and seconded by Mr. E. V. Buchanan "THAT the Convention badges be of the bar and ribbon type".—*Carried.*

Mr. E. V. Buchanan, Chairman Papers Committee, reported on behalf of that Committee and outlined papers available for the Convention. It was decided that five papers should be given during three Convention sessions as follows:

Thursday morning, June 22nd
—2 papers.
Friday morning, June 23rd
—2 papers.
Saturday morning, June 24th
—1 paper.

Mr. T. J. Hannigan advised that the O.M.E.A. would hold one session

only on the afternoon of Friday, June 23rd.

Mr. W. R. Catton, Chairman Convention Committee reported regarding proposed entertainment during the Convention. It was moved by Mr. O. M. Perry and seconded by Mr. W. M. Rogers "THAT there be a Convention dinner on the evening of Thursday, June 22nd and Convention luncheons at noon on June 22nd and 23rd," and "THAT the Convention Committee be authorized to spend $300.00 for entertainment". —*Carried.*

The Secretary advised of having reserved the dates of January 31st and February 1st, 1934, with the Royal York Hotel for the next winter Convention. The dates suggested were approved.

A report of a meeting of the Rates Committee at Brantford on September 20th, 1932, was read, and discussed. This report asked for interpretations of procedure under certain conditions, which were disposed of satisfactorily.

There being no further business the meeting adjourned at 4.30 p.m.

Programme of Convention

The programme of the Convention to be held at Windsor on June 22, 23 and 24 though not yet completed shows the following details arranged for.

THURSDAY, JUNE 22, 1933

Morning:

A.M.E.U. Session

Paper—"Wood Poles—Loading and Strength" by S. K. Cheney, Distribution Section, Electrical Engineering Dept., H.E.P.C. of Ont.

Paper—"The Starting of Polyphase Induction Motors from The Electric Utility Standpoint", by Wilson J. Wylie, Power Department, Toronto Hydro-Electric System.

Noon:—Convention Luncheon.

Evening:—Convention Dinner.

FRIDAY, JUNE 23, 1933

Morning:

A.M.E.U. Session.

Paper—"Operating Costs of Transformer Losses," by A. J. Magley, Chief Engineer, Moloney Electric of Canada, Limited.

Address:—"A Review of the Water Heater Campaign," by T. R. Jeffery, Chief Municipal Engineer, H.E.P.C. of Ont.

Playlett.

Noon:—Convention Luncheon.

Afternoon:—O.M.E.A. Session.

SATURDAY, JUNE 24, 1933

Morning:—A.M.E.U. Session.

Paper—"Grounds", by the Committee on Grounding of the H.E.P.C. of Ont., presented by Wills Maclachlan, Chairman.

THE BULLETIN

Published by
HYDRO-ELECTRIC POWER COMMISSION
of Ontario

620 University Ave.
Toronto

Subscription Price $2.00
Per Year

110,000 Volt Transmission Lines Aesthetically Designed

Ottawa and Vicinity

By A. E. Davison, Transmission Engineer, Electrical Engineering Department, H.E.P.C. of Ont.

FROM the point of view of amenities, a specially attractive type of steel transmission tower was used in Western Ottawa City (Westboro, Ont.). It forms part of a considerable 110,000-volt, 60-cycle system which was developed by the Commission a few years ago in an effort to give improved service by providing dual sources of supply and more particularly so that adequate power might be available to several districts, in each of which concern had been expressed regarding power reserves for the rapidly developing demand. These areas centred upon Ottawa, Smiths Falls and Kingston and extended from Cornwall, Alexandria and St. Anne de Prescott to Oshawa, Whitby and Pickering.

Power purchased from the Gatineau Power Company reaches Ontario near the Western boundary of the city of Ottawa. The same series of islands are used for this power interchange as are used for the new Champlain Bridge which forms part of the Federal District Driveway and Boulevard System which, although not yet completed, has added so materially to the beautifying of the capital city and its surroundings.

The towers are double-circuit type with the usual grounded wire at the top for protection against lightning if it should chance to strike close to the line. They are galvanized and support aluminum conductors through suspension insulators. The attractive appearance of these towers which are spaced about 600 feet apart is a curving of the main leg members so as to give that graceful effect usually associated with that famous Eiffel observation tower of Paris. The majority of the towers are about 75 feet high; however, the towers at Bate and other islands which must provide the required clearances for navigable rivers are 208 feet high.

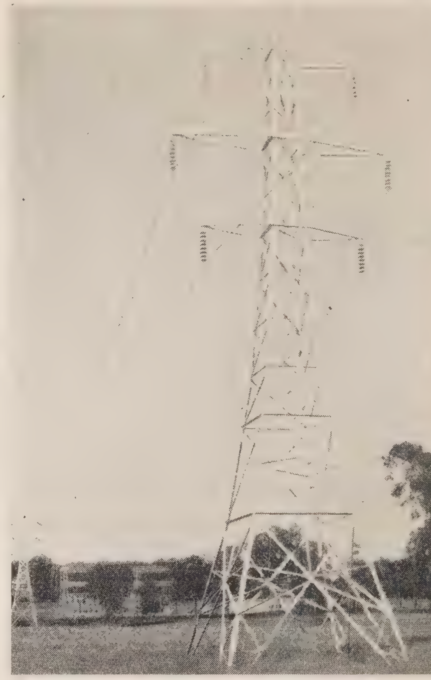
Towers of this type are nearly as efficient mechanically as the more standard types and are only a little

CONTENTS

Vol. XX No. 5

May, 1933

more difficult to manufacture and assemble. In securing the graceful effect other attractive features must be sacrificed as it is generally recognized that towers having a very wide top with a grounded wire at each side of it and with middle power arm shorter than the upper and lower arms are more effective electrically.



Typical Tower, 110,000-volt Ottawa Station in background.

The springtime silhouette of one of the high river crossing towers and neighboring trees offers a study of all details. This structure takes care of a small angle in the line and as well provides dead-ending facilities for the crossing cables. Permanent ladders are not provided. Ladders would

Ottawa River crossing construction from Champlain Bridge.

Distribution lines of the Ottawa Hydro-Electric Commission leaving Carling Avenue Station.

improve maintenance conditions; however, they are omitted so as to minimize trouble due to mischievous climbers. The concrete piers which are designed to extend above high water and ice marks are also designed to keep careless climbers away from the power wires. It can be seen in this view that the leg angles are not actually curved, but are rather a series of tangents.

Another view shows an anchor tower with men at work in the foreground. The approach to the Champlain Bridge from the Ontario side is seen while in the distance the tops of the two main crossing towers can be seen.

The standard construction on this line is exemplified in the third photograph. Angle sections are used throughout excepting the straps or flat plates which support the end of the arms.

In the background, parts of the 110,000 volt station serving the city of Ottawa can be seen.

O.M.E.A - A.M.E.U.
Summer Convention
at Windsor, Ont.
June 22, 23 and 24, 1933

Hydraulic Design—Chats Falls Development

By O. Holden, A.M.E.I.C., Assistant Hydraulic Engineer, H.E.P.C. of Ont.

(From paper presented at the General Professional Meeting of the Engineering Institute of Canada at Ottawa, Ont., February 8, 1933.)

THE Chats Falls power site includes the fall in the Ottawa River between Chats Lake and Lake Deschenes. There are three natural divisions to this section of the river; first, a two-mile section immediately below Chats Lake having a drop of some twelve feet; second, a wide level stretch of river having an area of approximately one square mile, known as Fishery Pool; and third, the Chats Falls proper in which occurred under natural conditions a drop of approximately thirty-eight feet to the level of Lake Deschenes. Since a general description of the development has been included in the first paper of this series, it will be unnecessary to go further into detail concerning the site.

The features of the development which are to be dealt with in this paper are, as implied in the title, mainly those concerning hydraulic design. Under this heading has been included a description of the arrangement and the essential features of design of the water controlling structures and the hydraulic equipment.

Main Dam

The dam is constructed on the ledge of rock which forms the main falls and rapids. It is U-shaped in plan, extending approximately one mile upstream on either mainland to reach the supporting contours. The location was in part governed by the site chosen for the power house which is placed astride the interprovincial boundary and adjacent to tailwater level. The location chosen, which gave the minimum estimated cost, crosses a series of islands and channels a short distance downstream from the rock ridges controlling the elevation of Fishery Pool, and reduces the backwater effect on the latter, and consequently on Chats Lake, during periods of high flow. These ridges offered favourable sites for the necessary cofferdams.

The structure, which is approximately 16,500 feet in length, was designed for a water level of 247.0, Geodetic Survey of Canada datum. It consists essentially of a number of concrete bulkhead and sluiceway sections terminating in an earth dyke on the Ontario shore. The sluiceway sections include seventy-four stop-log sluices, four gate-controlled sluices and a log slide. The main features of these various elements are briefly described hereunder.

Bulkhead Section

The bulkhead section of the dam was constructed with a vertical upstream face, a top width of 5 feet at elevation 250.0, and a vertical downstream face from the top to elevation 245.0, below which there is a batter of 8 in 12. The total length of bulkhead

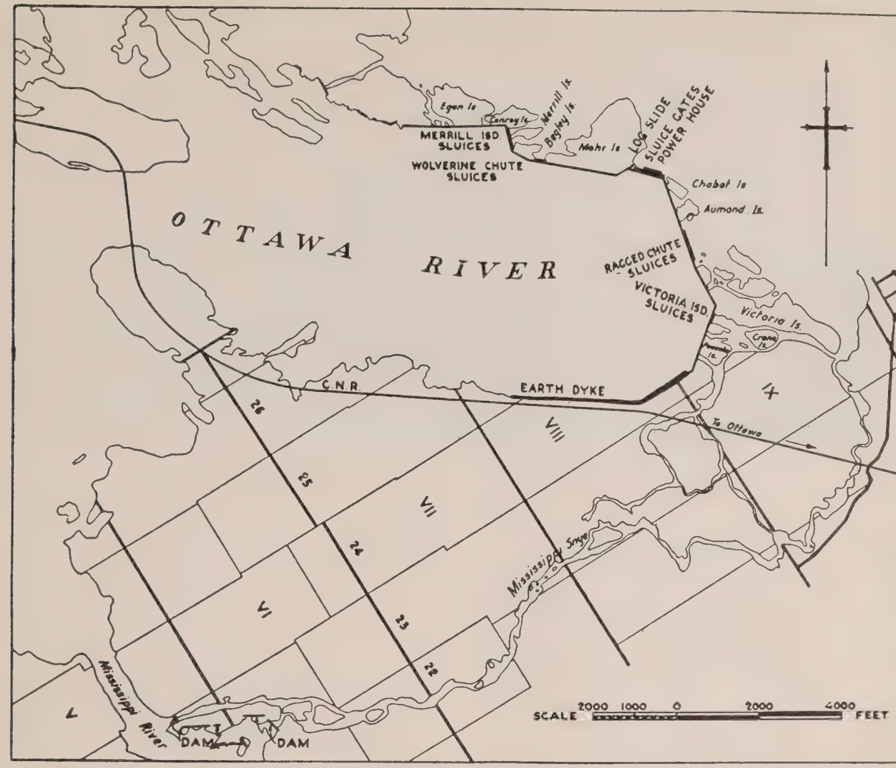


Fig. 1.—General Plan of the Development.

section is 9,400 feet. The maximum height is 45 feet, and the average height is approximately twenty-five feet.

Transverse construction joints were provided at 40-foot centres and were rendered watertight by means of keyways and a coating of a plastic asphalt compound. Each section was poured continuously to the full height of the structure. This eliminated the problem of rendering watertight the usually troublesome horizontal joints.

The section was designed with an allowance for uplift varying from two-thirds of the static head at the upstream toe to zero at the downstream toe, and an ice thrust of 5,000 pounds per lineal foot at elevation 246.0, in addition to the horizontal water pressure.

Stop-Log Sluices

There are four series of stop-log sluices totalling seventy-four in all, each sluice having a clear opening of 18 feet. These sluices are located in the main natural channels. The sills are at elevation 225.0, and the top of the deck at elevation 251.33. Forty-two of these sluices are located on the Ontario side of the river, and thirty-two on the Quebec side. The piers are 6 feet in thickness, and were stream-lined on the upstream edge to provide a smooth entrance for the water. The decks are flat concrete slabs continuous over two sluices.

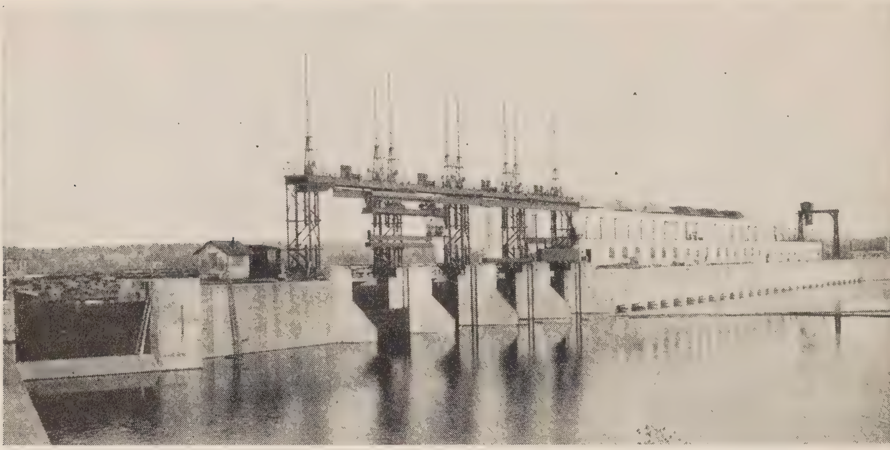


Fig. 2.—Upstream Elevation of Sluice Gates and Power House.

The stop-logs are 18 inches thick at the sill, varying to 12 inches at water level, and are handled by electrically operated spud winches travelling on standard gauge tracks. In the design of the sluiceway section the same factors were considered as for the bulkhead section. Reinforcement was placed in the piers where necessary, to prevent contraction cracks.

Gate Sluices

Immediately west of the power house are located four sluices, controlled by gates of the fixed roller type, each equipped with its own hoisting mechanism. The clear opening between the piers supporting the gates is 40 feet, the sills are at elevation 223.0 and the top of the gates are at 248.0. The piers are 10 feet thick, and streamlined on the upstream ends, which are protected with heavy steel angles up to elevation 237.0. Above this point the piers slope at an angle of 45 degrees, and are heavily armoured to assist in the breaking up of ice floes which may be carried against them. Emergency stop-log checks are located a short distance upstream from the main gate checks, and structural steel gates in sections of convenient height, handled by means of a monorail hoist, are provided for unwatering the gates when necessary.

The deck consists of a reinforced concrete slab 10 inches thick, supported on I-beams, and is located down-stream from the gate checks. In addition to serving as a convenient passageway and working platform, this deck adds lateral support to the main piers.

These sluices, which have a discharge capacity slightly greater than the full load discharge of the power house, provide a ready means of regulating daily variations in river flow and power house discharge, and permit of a minimum of stop-log operation, which is of particular advantage during the winter period.

To ensure operation under low temperature conditions, the gates are closed in on the downstream side and

heated with electric space heaters. The checks are also protected by electric heaters in vertical chambers located in the piers adjacent to the roller paths and sealing rods, and forming a part of the embedded check steel.

Log Slide

A short distance west of the gate sluices is located a concrete log slide intake 30 feet wide, with the sill at elevation 236.5. This has been designed for the installation of a drop gate, but at present is closed off by the use of steel stop-logs. A timber log slide approximately two hundred feet long has been built from the intake to tailwater.

Earth Dyke

The earth dyke, which is the upstream extremity of the dam on the Ontario shore, is located on Chats Island, and is approximately four thousand three hundred feet in length. The structure is located on a heavy layer of impervious clay, which extends down to bed rock. It is constructed of this same clay secured from adjacent borrow pits and spread in layers. Each layer was thoroughly compacted by the heavy tractors and trucks used for transporting and spreading the material. A cut-off trench was provided along the centre line of the base, which latter was stripped of all loam and vegetable matter and ploughed before placing any fill material. The upstream face is protected by a heavy layer of hand-placed rip-rap of waste rock from the power house excavation and the unloading of cofferdams. The junction with the concrete bulkhead section of the dam is made with a specially designed U-abutment.

Discharge Capacity

The maximum discharge capacity of the dam is dependent on the elevation of Fishery Pool, which level, in conjunction with the loss in the river section above, controls the elevation of Chats Lake. With the sluices above described and by virtue of their location, together with the improvement in the channel at the outlet of the lake effected by the excavation of a large quantity of rock at the control section, it is possible to maintain Chats Lake at or below the natural level for any discharge. The maximum flood within the period of record occurred in 1928, when a flow in the neighbourhood of 200,000 c.f.s. was reached.

Auxiliary Dams

Two small concrete dams were required to close the high water channel or snye of the Mississippi River which empties into Chats Lake immediately above its outlet. One of these dams is of the bulkhead type, while the other has two 16-foot sluices controlled by stop-logs and equipped with hand-operated winches.

On the Quebec mainland several sections of bulkhead were constructed across low areas. The largest of these was to close a channel which had been excavated about 1854 for a navigation canal.

Power House Headworks

The headworks or intake section of the power house is incorporated in the main dam, and has been designed for an ultimate installation of ten

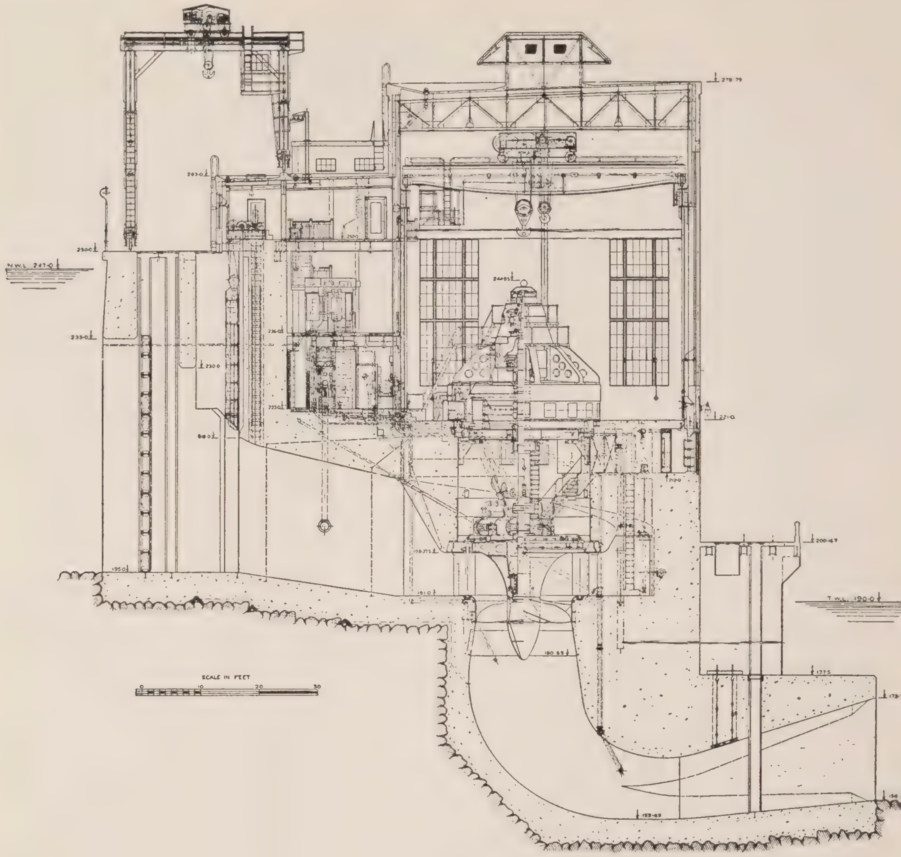


Fig. 3.—Cross Section through Power House on Centre line of Unit.
Data—Number of units installed—8. Rated capacity—53 feet head—28,000 h.p. Head—38 to 58 feet. Speed—125 r.p.m. Discharge—5,300 c.f.s. Runner—propeller type—Cast Steel. Number of blades—6. Governor—Morris Pelton No. 4. Turbine manufacturer—Dominion Engineering Works. Generator capacity—23,500 kv.-a. Generator manufacturer—Canadian Westinghouse Co.

units. Fig. 3, showing a cross-section through the power house, indicates the relation of the headworks to the power house proper. There are three water passages per unit, each 15 feet in width and 40 feet in height to the under side of the curtain wall. Immediately downstream from the curtain wall, which is of substantial thickness to withstand ice thrust, are located the racks, which are of unit construction split horizontally into three sections and readily removable. The spacing of the rack bars is 6 inches centre to centre and these, together with the rack frames, are designed for a 10-foot head. The racks are supported in steel lined checks. Downstream from the rack checks and immediately upstream

from an intermediate concrete diaphragm wall are checks for the steel stop-logs to be used for unwatering the headgates. The intermediate diaphragm forms a top seal for these emergency stop-logs, and is of material assistance in transmitting the reactions from side pressure on the main piers between units.

The headgates close an opening 15 feet wide and 23 feet high, and are of the fixed roller type, somewhat similar to the sluice gates but with the skin plate on the downstream side. Remote control apparatus enables them to be lowered from the control room. A small extension of the main power house superstructure, enclosing only the headgate hoists, permits of heating the headworks. Timber covers are provided for the deck openings, and ports have been left in the intermediate diaphragm and curtain wall to enable the warm air from the power house to pass over the water above the racks. The headgates may be shifted upstream on two removable trolley-beams to a point clear of the superstructure wall, from which location they can be hoisted clear of the headworks deck by a 30-ton outdoor travelling gantry crane. This crane also handles the racks and steel stop-logs by means of a follower travelling in the checks, which can be attached to or released from the gates or racks from the headworks deck.

A breast wall 7 feet 6 inches in thickness separates the headworks from the power house proper. In this breast wall are located three air vents and one manhole for each unit. This manhole, with an adjustable ladder, provides access to the supply pipe and scroll case when the head-gates are lowered.

There are three spare sections of racks and sufficient emergency gates for one unit. In case it becomes necessary to remove racks for cleaning, the three spare sections may be dropped into the emergency gate checks immediately downstream from the rack checks, thus protecting the opening while the regular racks are removed.

The headworks main piers have been designed as restrained beams to resist the side pressure resulting from water at maximum level. The floor of the intake was designed as an integral part of the whole structure and reinforced accordingly for vertical water loading. Under-drains were provided below the intake floor by a system of lateral and longitudinal boxes which discharge through off-takes into the tailwater.

Power House Substructure

The power house is located with the transverse centre line coincident with the boundary between the provinces of Ontario and Quebec and, as at present constructed, extends over eight units, which are spaced at 62-foot centres. The substructure is constructed entirely of reinforced concrete, in which are formed the draught tubes, scroll cases and generator air ducts.

Draught Tubes

The draught tubes are of the elbow type and extend 30 feet downstream from the power house wall, or 60 feet from the centre line of the units. The lowest point of the tube is about 38 feet below normal tailwater level,

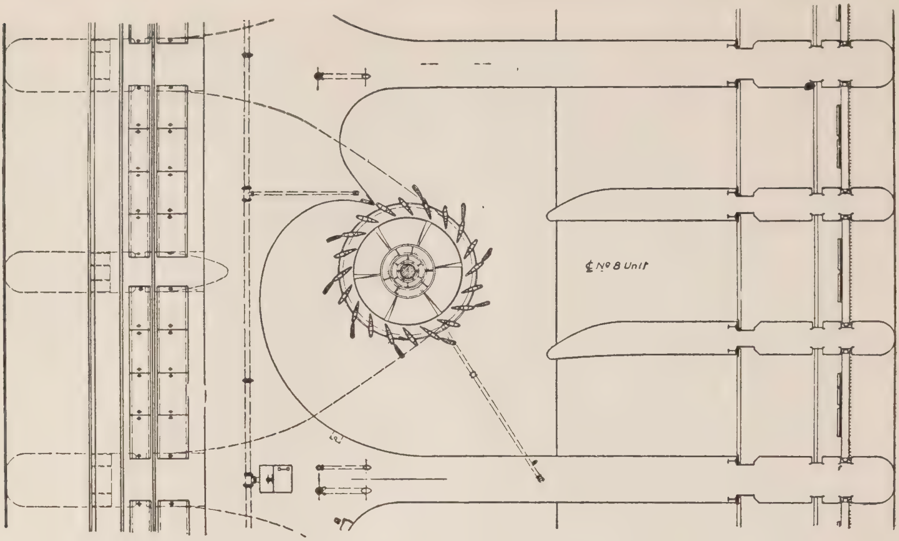


Fig. 4.—Sectional Plan of Unit through Water Passages.

sloping up 3.6 feet at the downstream end. The tube is 10 feet 6 inches in height at its lowest elevation, and the flare in the roof gives an exit opening 17.5 feet in height. The main piers between draught tubes are 8 feet in thickness, and an intermediate pier 6 feet wide, forms two water passages 24 feet in width at the exit.

As the floor of the scroll case is approximately at normal tailwater level, the runner is submerged at all times. It was therefore necessary to provide means of unwatering the runner for inspection and repairs. To this end, gate checks were installed in the draught tube extension piers, into which steel stop-log gates may be placed, and the draught tube unwatered. Sixteen structural steel gates, each 5 feet in height, are supplied for this purpose, and are stored underneath the tailrace deck. At each unit there are two openings, 4 feet by 6 feet, in the draught tube deck adjacent to the middle piers, to give access to the draught tube. These openings are blocked off by structural steel covers flush with the ceiling of the draught tube. Structural steel covers, filled with concrete, were also placed in the gate checks to prevent the circulation of water between the draught tube and the area above. The tailrace deck is a reinforced concrete slab supported on steel beams and carrying a standard gauge track. This track furnished access across the power house site during construction, and now serves to handle tailrace gates by means of a locomotive crane through the medium of a follower.

Scroll Cases

The scroll cases are of the usual reinforced concrete type. The floor being horizontal, both design and construction were greatly simplified.

Air Intakes for Generators

There are two ducts for supplying

cooling air to each generator. These ducts lead from openings in the downstream power house wall to the turbine pits underneath the generators. At the point of entry to the turbine pits each air duct is 7 feet high and 6 feet wide. At the level of the floor of the ducts there is a passageway extending the full length of the power house, and equipped with steel doors midway between each unit.

To allow of access to the turbine pits, four stairways, each serving one pair of units, lead from the generator room floor to the air duct floor, from which level removable steel stairs descend into the turbine pit. Self-closing sliding steel doors are installed at the entrance from the stairway to the air duct, thus effecting a totally enclosed air cooling system for each generator. Openings in the power house floor over the air ducts allow a portion of the air in the generator room to be re-circulated through the generators if desired.

Hydraulic Equipment

Turbines

The present hydraulic installation comprises eight turbine units with their attendant controlling and auxiliary apparatus. Each turbine has a rated capacity of 28,000 h.p. under a head of 53 feet and at a speed of 125 rev. per min. The discharge per unit for this rated capacity and head is 5,300 c.f.s. The operating head on the units varies from 38 feet at times of very high river flow, to 58 feet at low flows. The head at which the turbines are rated, namely 53 feet, was selected after a careful study of the water levels and the duration of various stages of the river. The capacity of the units was fixed from a consideration of the best use of the water available throughout the year, the speed of the units, and the requirement for an equal number of units on each side of the interprovincial boundary.

The turbine speed rings, which are of the built-up type, are set in the concrete scroll cases. The propeller type runners are set one foot below low tailwater level, and are consequently submerged at all times. The throat ring surrounding the runner is made of a machined 2-inch steel plate, in four sections. These sections are securely bolted together and the joints welded and ground. To the bottom of this ring is fastened the steel plate liner, forming the upper portion of the draught tube.

The stay vanes (ten in number), stay ring and pit lines were erected on the floor of the scroll case, which had been previously poured, and were concreted in place with the upper portion of the scroll case. Voids were left for the later setting of the lower distributor ring, throat ring and draught tube liner. The head cover was used for the proper centering of these members.

The turbine gates, twenty in number, are of welded plate steel construction. The height of the gates is 7 feet 4 inches, and they are fitted with forged steel shafts extending through the head cover. The latter is of cast iron, and is made in three pieces to facilitate removal. The centre portion of the head cover provides the support for the main bearing, which is of the adjustable lignum vitae type. Water for the lubrication

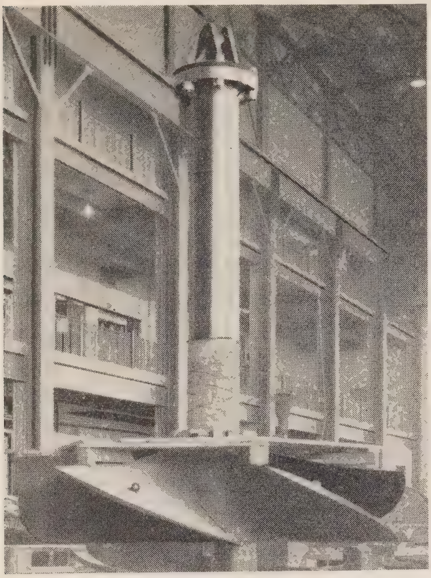


Fig. 5.—Turbine Runner and Shaft Ready for Installation.

of this bearing is normally drawn from the scroll case, an emergency supply being provided by a connection to the generator bearing cooling system.

The servo-motors are located in close proximity to each other, adjacent in plan to the governor actuator, which arrangement greatly simplifies the piping and turbine pit layout.

The only auxiliary equipment located within the turbine pit is the circulating pump for the generator bearing oil. This feature, together with the servo-motor layout mentioned above, simplifies the arrangement of the stairway and operating platforms, and facilitates the inspection of the turbine operating mechanism.

The turbine runners are of the Moody high speed propeller type, having six fixed blades. They are solid steel castings with an outside diameter of 16 feet 2½ inches. A heavy cast iron cone is attached to the lower side of the runner, to properly diffuse the flow at exit from the runner.

Governors

Each turbine is controlled by a Morris-Pelton governor. The actuators, which have a rated capacity of 80,000 foot-pounds per second, are located on the main power house floor, in alternate spaces between their respective pairs of units. This arrangement permits the use of the remaining spaces between units for the erection and dismantling of equipment.

The flyballs in the actuators are motor driven by current supplied from the generator leads through potential transformers. They are equipped with the usual load limiting and shut-down devices, the latter being arranged to operate in conjunction with the generator protective relays. Hand operated hydraulic control is arranged for regulation of the unit when the actuator is out of service.

A small capacity high pressure air compressor is also installed for supplying air to the accumulator tanks when required.

Auxiliary Hydraulic Equipment

In addition to the main turbine and generating equipment and appurtenances, there is installed or provided auxiliary equipment of various types. This includes for outside use four electrically operated stop-log winches of the spud type on the sluiceways, a 30-ton motor-operated gantry crane

for headworks operation and a gasoline-driven locomotive crane for handling tailrace gates and for general yard service. Inside the power house there is installed, as already noted, a high pressure air compressor.

To ensure drainage of the turbine head covers for all conditions of tailwater and gate opening, an auxiliary drain from each head cover is taken to a drainage header extending the length of the power house and emptying into two sumps located between Units Nos. 2 and 3 and 8 and 9. In addition, certain floor drains empty into these sumps. Each drainage sump is provided with a motor-driven vertical centrifugal pump discharging into the tailrace and arranged for float-switch control.

With the turbine runner set below tailwater level, it is necessary to lower the water in the draught tubes for inspection. For this purpose, a 1,500-gallon shaft sinking pump is provided, which will operate through the openings in the tailrace deck already described.

Appurtenant Works

Permanent Railway

A standard gauge railway connects the power house with the Canadian National Railway near Fitzroy station. This railway has a length of one-and-a-half miles, and all structures are designed for E-40 loading. Two plate girder spans carry the track over the channels at Victoria Island. From Victoria Island to a point near the power house, the track is located close to the downstream side of the dam. It crosses Ragged Chute sluices on steel beams supported on extensions to the sluiceway piers, and over the old river bed on either side of the sluices on timber trestles with concrete foundations carried above water level. It is intended that these and other trestles will be filled when required.

A 72-foot plate girder structure spans from the transformer turntable to the power house entrance, and carries additional rails at wide gauge to accommodate the transformer transfer truck, which can thereby be brought under the power house cranes. This span is so designed that it will permit of the installation of an additional unit without serious interference with the operation of the plant. Inside the power house the standard gauge track is carried the full length of the structure on the downstream side of the main units.

A switchback immediately east of the power house provides connection to the tailrace deck, which also carries a standard gauge track for its full length.

Automatic Recording Gauges

In order that the operators may at all times have immediate and accurate information as to the water levels, automatic indicating and recording gauges have been installed on Chats Lake, at the forebay and on Lake Deschenes.

Portage

To aid passage of small boats and merchandise, a substantial timber structure has been constructed over the dam at the site of the old Indian portage on Conroy island, and the portage itself graded and improved. This route past Chats Falls was used

by the Indians in early times, and by the lumbermen and others in later years, and it is believed that Champlain travelled over it on his voyage of discovery to Georgian Bay.

Lighting and Railings on Dam

There are protective railings on the headworks and dam from the power house to the farthest sluices. On the bulkhead sections the railing is located on the upstream side only, while the decks of all the sluiceways are protected on all sides. The railing is constructed with cast iron posts and two through rails. The posts are located at 8-foot centres, and lights have been installed at 72-foot centres on the bulkhead sections, 48-foot centres on the sluiceways and at 21-foot centres on the headworks. The lighting standard is made as an extension to the railing post, and the wires are supported by messenger cables carried on the back of the dam and run through conduits to the centre of the posts. Power cables for the winches are similarly arranged, with outlet boxes located at posts on the upstream railing at the sluices. Telephones with siren calls are located at each sluiceway for convenience.

Railway Re-Location

To accommodate the proposed headwater level, it was necessary to either raise or re-locate a section of the Canadian National Railway main line along the Ottawa River west of Chats Falls. It was found that a re-location inland to higher ground offered the most satisfactory solution. Under agreement with the railway company, a new track some two miles in length was constructed to standard main line specification. Minor protection works were also carried out at other locations, including the water-proofing of the railway bridge piers at Lavergne point.

General

Construction of the plant was started in October, 1929. The first units were placed in commercial operation in the fall ot 1931 and the final installation was completed a year later, following which tests on the equipment were made. To enable the measurement of turbine discharge by the Gibson method, and for flow record purposes, manometer connections were installed at suitable locations in the supply pipes and scroll cases. The scroll case connections may be calibrated from the turbine test data to give a continuous record of turbine discharge.

The writer, as assistant hydraulic engineer of the Hydro-Electric Power Commission of Ontario, was responsible for the engineering and design of the works covered in this paper, and was assisted throughout by S. W. B. Black, A.M.E.I.C., as designing engineer. Acknowledgment is made also of Mr. Black's assistance in the preparation of this paper.

Application of Electric Drive to Governor Flyballs

As used on Hydraulic Turbine Governors

By H. H. Leeming, Assistant Engineer, Electrical Engineering Department, H.E.P.C. of Ontario.

THE following has been prepared in an endeavour to present a somewhat condensed article covering the development during the past ten years or so, in governor head drives starting with the original belt drive and concluding with the motor drive using the recently developed and promising Permanent Magnet Generator for the power supply, which system was placed in commercial use for the first time on one of the 18,000 h.p. generating units at the Hydro-Electric Power Commission of Ontario Alexander Development.

The following should not be construed as a new article or a thesis on this subject, but more as a condensed summation of the articles prepared on governor head drives by the manufacturers, supplemented by information obtained from preliminary and final tests made by the Hydro-Electric Power Commission and the Woodward Governor Company on the two most recent electric governor drives.

It is generally understood that to ensure perfect governing any slight change in the speed of the main generating unit must be transmitted instantly and accurately to the governor head, which constitutes the controlling element of the governor system and the governor must assure stability during the adjustment period.

Belt drives of careful construction will answer the purpose, especially in the case of horizontal units, and it is a well known fact that such drives have given satisfactory regulation in plants operating for more than two decades. Since, in modern plants, preference has been given to single vertical units, the belt drive became complicated due to the governor being placed on the generator floor, while the drive is usually located in the substructure. The direct-connected mechanical drives which have been developed do not always satisfy the desired features of simplicity, and rotating parts placed on vertical shafts, transmitting to reciprocating movements on the governor usually require massive construction and may cause sluggishness. The electric drive was therefore the desired step to transmit relatively low speed into high speed. The element of unnecessary friction is thus obviously reduced to a minimum.

The application of electric drive from the generator through transformers was only the first step to answer the purpose, and through finding out its faults in operation, the final answer was the development of an inexpensive auxiliary generator placed directly upon the generator shaft and acting independently and directly upon the governor flyball.

Complicated protective devices should be kept to a minimum to assure safe operation and as little attendance as possible. Such requirements are of vital importance in remotely controlled plants. Damping devices, if such are necessary for other reasons, must be cut out of action at the crucial moment and should only be called upon to come into action to iron out small oscillations after load adjustment has been accomplished.

A member of great importance in the governing system is the restoring device. This should be as short as possible, and, for this reason, a governor should be located as close to the gate operating apparatus as possible. Keeping the foregoing in mind and having in view a vertical unit, the flyball drive becomes complicated and the electric drive is the natural selection.

Types of Drive

The most commonly used governor head drives can be classified under three headings, viz., belt, including horizontal and vertical belt-drives; direct connected mechanical drive; and the electrical drive, which system requires motor driven flyballs, the motor being supplied through potential transformers of the required rating off the station bus or generator mains.

For the more recently developed motor drives the governor flyball motor is supplied with polyphase a.c. power from taps off the armature of a pilot exciter, or from a specially built permanent magnet a.c. generator which is directly connected to the main unit.

Belt Drive

The belt-drive system which is the oldest type of drive used, requires care in the selection of pulleys on the main unit and governor to guard against the belt running off, this being especially true in the case of vertical units. The selection of belt material also requires careful consideration based on operating experience. This system of drive dictates, to as great an extent as the restoring mechanism, the location of the governor with respect to generating unit. There is usually considerable maintenance necessary, bearings require daily attention and operating costs are comparatively high. There is the racy condition caused by the unevenness of belts to be contended with, the hazard of belt breakage and the attention necessary to prevent belts from becoming loose. On most installations a slip of 1 to 1½ per cent. is considered normal.

Most engineers connected with power development can, however, visualize a number of installations where belt-drives have been in service for years with results which are considered more or less satisfactory.

Mechanical Drive

In an endeavour to overcome some of the objectionable features of the belt drive, a direct connected mechanical drive was developed by certain concerns. The mechanical drive mechanism dictates to a great extent the location of the governor with respect to the main unit. On some systems the governing flyballs are mounted on the shaft of the main unit and movement of same

transmitted by shafts to the governor regulating valves. On other systems the speed of the main unit is transmitted by means of gears and shafting to the flyballs on the governors.

Usually, mechanical drives require the use of a complication of shafts, gearing and bearings which require daily attention. The initial cost of installation and annual maintenance is higher than for most electrical drives and the system is not as sensitive.

Electrical Drive

An axiom in generating unit regulation is that the speed of the governor flyballs should be in exact synchronism with the speed of the main unit for the best results. This objective is most closely reached by the electric motor drive, which is more accurate and has none of the objectionable features of other types of drives.

With the motor-drive the location of the governor with respect to the main unit is not governed by drive alignment. It is very smooth in operation and if voltage is maintained is unaffected by anything, except frequency.

The motor-driven flyball system as most commonly used requires the use of high voltage potential transformers with protective equipment, usually consisting of resistors and fuses in the primary. A failure in the potential transformers or connections may result in the speed of the main unit going considerably above normal under certain conditions, with possibly serious consequences. Such failures fortunately, however, seldom occur.

With the potential transformers connected off the generator mains or station bus, there exists a possibility of losing control of the unit in the event that the generator gets out of step with the system to which it is connected. A condition of this kind sometimes occurs as a result of a sudden drop in frequency or voltage. The reserve generator capacity on the system, the flywheel effect of the units, the field strength and exciter response and nature of the disturbance all affect the stability of the units.

The flyball motor connected as described above will usually follow the system frequency instead of the generator in case of such instability and hence the governor is useless to control the main generating unit.

In such cases, the action of the governor is usually to aggravate the situation instead of helping, for instance, if the generator maintains its speed when the system frequency drops, the governor may follow the system speed and "slow up" the flyballs, thereby opening the gates wider and increasing the speed of the generating unit. This fault is serious in automatic stations and for this reason reliable overspeed control devices must be included. The fault is also often quite serious in manually operated plants.

Of recent years, numerous governor installations have included the motor-driven governor flyball system and the performance has been found very satisfactory with very little maintenance and attention being necessary. The susceptibility of this governor drive system to station or main system disturbances and the possibility of such a drive system

aggravating conditions at the time of system disturbances as stated above is an inherent characteristic.

Later Types of Electrical Drives

In view of the above certain governor manufacturers were anxiously looking for a source of power for governor motor drive which would obviate any possible trouble.

With the advent of the pilot exciter, about 1927, as a direct result of the trend towards faster response in generator voltage regulation, the idea was conceived of taking a 3 phase tap off the armature of the pilot exciter to three slip rings mounted thereon. From these rings, power is transmitted direct to the flyball motor, causing same to be run at a speed exactly proportional to the speed of the main unit.

This provided a comparatively cheap and convenient source of supply for the governor head drive and it was expected that such a system would be unaffected by line or station system disturbance.

Quite a large number of pilot exciter drives have been built and placed in operation with, from reports received, satisfactory results. Only on one or two installations were electrical adjustments necessary.

Subsequent to the installation of the first pilot exciter drive systems, electrical manufacturers found that on a heating basis the size of the pilot exciters could be considerably reduced. In other words, a pilot exciter design was worked up wherein the pilot exciter would not overheat in normal operation and which would commutate properly even when subjected to the momentary excessive overload resulting from the demand of the extra high speed generator voltage regulator. An exciter of this design will likely prove unsatisfactory as a source of supply for a governor head motor.

The pilot exciter system of governor drive is complicated electrically and in considering the application of same for any installation, the characteristics of the main generator, exciter, pilot exciter, voltage regulating equipment and governor head requirements should be carefully studied in cooperation with both the generator and governor manufacturers.

OPERATING EXPERIENCE

On placing the pilot exciter supply system of governor-drive in service on a generating unit furnished with a pilot exciter of modern design and having inherent characteristics which were later found unfavourable to this system of drive, trouble was encountered.

Theories at first advanced and subsequently confirmed by oscillographic studies were that any sudden load change on the pilot exciter, due to voltage regulator operation, synchronizing or sudden load changes, caused a distortion in the field form of the flux in the air gap of the pilot exciter which showed up as a distortion in the a.c. supply at the slip rings of the pilot exciter. This resulted in a disturbance in the governor head motor which caused a heavy surging in the servo-motors of the turbine.

This extreme case was encountered with the pilot exciter supply when tried out on one of the 15,000 kv-a. generating units of the H.E.P.C. Alexander Development.

The main unit has 72 poles, 100 rev. per min., 60 cycles. The main exciter is rated 165 kw., 250 volts, 8 pole, and the pilot exciter 6 kw., 250 volts, 8 pole. The capacity of the main exciter is ample for the main generator excitation and the pilot exciter has an overload rating sufficient to carry peak excitation of the main exciter. With an 8-pole exciter operating at 100 rev. per min., the frequency at the slip rings is 6.7 cycles per second. The induction type governor flyball motor is a 2-pole unit with a normal operating speed of 400 rev. per min.

The governor head motor in the case of the above system is electrically connected through the exciters with the output of the main generator. The result being that any transient disturbance in the output of the main generator was reflected to a greater or lesser degree in the motor driving the flyballs. If a sudden demand for load was made on the pilot exciter, this load could be supplied partly from the pilot exciter itself and partly from the governor motor, thus causing an oscillation of the motor in its attempt to supply power to the system requiring it.

The oscillation of the governor motor was exaggerated by a number of conditions as follows, which are set forth in the order of importance.

(1) The motor was of necessity two-pole which allows one electrical degree of oscillation to be equal to one mechanical degree in the motor. The motor can oscillate through a relatively large mechanical angle and still remain in synchronism with the system, which all the tests indicate that it did.

(2) The pilot exciter is relatively small for the short time load demands made upon it and is not provided with interpoles or a compensating winding. As a result there was considerable voltage distortion in the pilot exciter during the momentary large changes in output and this aggravated the oscillation which occurred on the governor motor. The design of the main exciter field is such that the field has very few ampere turns relatively, this design being apparently for the purpose of getting maximum response when the voltage regulator operates. The result is that the load on the pilot exciter can and does change very rapidly which caused an oscillation in the governor motor as noted above.

(3) The controlling resistance in the main exciter field is of the Wheatstone bridge type which from the point of view of voltage regulator operations is a very successful arrangement but which appeared to aggravate the trouble in the governor motor due to the fact that it allows a very rapid building-down of voltage and output of the exciter. It is interesting to note that it requires 2.1 seconds for the pilot exciter amperes to build up but only .11 second to build down when the regulator contacts are open or about 20 times as fast to build down.

Tests with Pilot Exciter Supply

Fig. 1 is a reproduction of an oscillogram taken during the investigations in connection with this drive system at the Alexander Station and illustrates what takes place each time

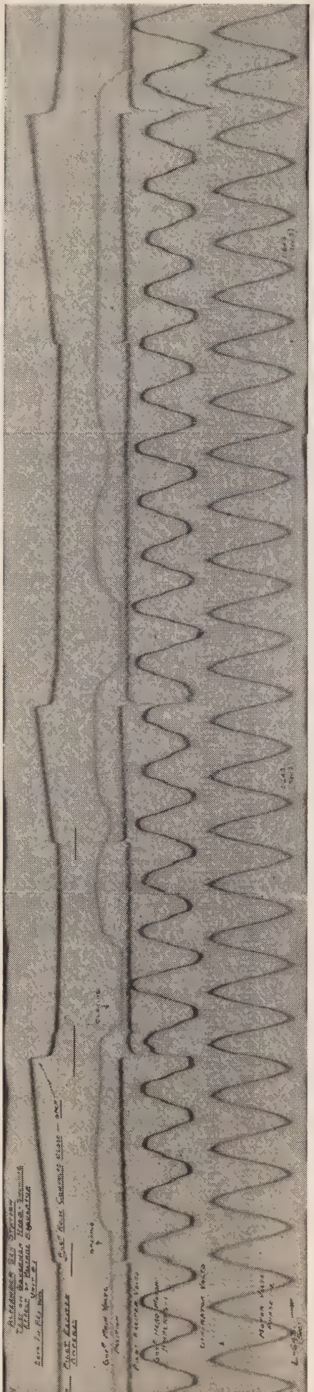


Fig. 1—Test on governor head showing effect of voltage regulator.

the voltage regulator is operated. Reading from the top of the oscillogram downwards the first curve is that of the pilot exciter load current which of course is the exciter main field current. The second curve represents the governor main relay valve movement.

The third curve is that of the pilot exciter d.c. voltage. The fourth curve represents the alternating current in one lead to the governor head motor. The lower curve is the a.c. voltage at the slip rings of the pilot exciter which voltage is supplied to the governor head motor.

Inasmuch as the governor relay valve was limited in its actual travel by mechanical stops adjusted to give a particular time of turbine gate opening or closing, the straight horizontal portion of the second curve from the top indicates the governor relay valve at that time was hard against the mechanical stop and therefore the possible full travel of the relay valve is not indicated.

As a study of what takes place, assume that 1/10 of a second is required for the pilot exciter field to become distorted. The a.c. voltage phase shift in the above case was about 12 electrical degrees. A phase shift of 12 electrical degrees in 1/10 of a second is equivalent to 1/3 of a cycle per second on the 6.7 cycle pilot exciter which is equivalent to approximately 5 per cent. actual frequency change. The latest type governors are sensitive to approximately 1/50th of one cycle speed change on 60 cycle frequency. Therefore, the sensitivity of the governor is approximately 0.033 per cent. It can be readily seen therefore that a 5 per cent. speed

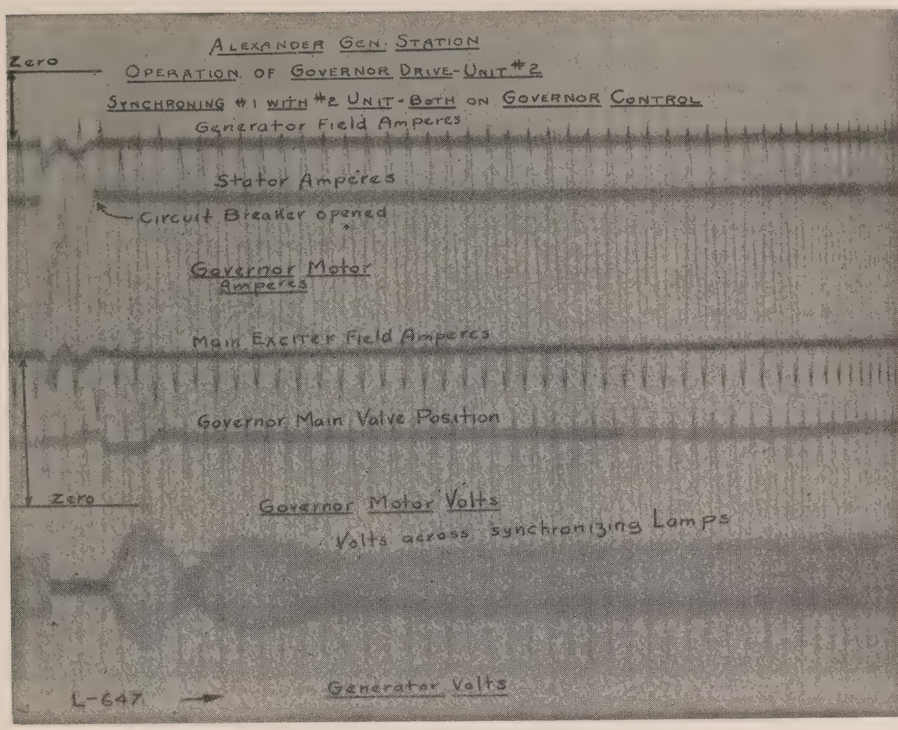


Fig 2.

change of the governor drive motor even though the speed change is almost instantaneous will create considerable disturbance on a governor which is sensitive to 0.033 per cent.

The surging of the governor due to the distortion of the field flux of the pilot exciter was not only experienced each time the voltage regulator operated but also when a generator was synchronized to the bus. This was tried out, using an oscillograph to obtain a record of the performance.

The oscillograms Fig. 2 and Fig. 3 illustrate the disturbance when synchronizing one 15,000 kv-a. generator with a duplicate generator with both generating units off load.

The generators were paralleled slightly out of phase in order to obtain an oscillation between the units and exaggerate conditions.

In the case of Oscillogram Fig. 2, the flow of synchronizing current was so great that protective relays operated separating the two units after approximately ½ second. On this record the variation in generator field current and main exciter field current which is proportional to the output of the pilot exciters is clearly shown as well as the variation in position of the governor main valve.

Oscillogram Fig. 3 shows the results of a repetition of synchronizing between the two units with the No. 2 unit on governor control.

In this case, the units remained in synchronism with a transfer of synchronizing power which was damped

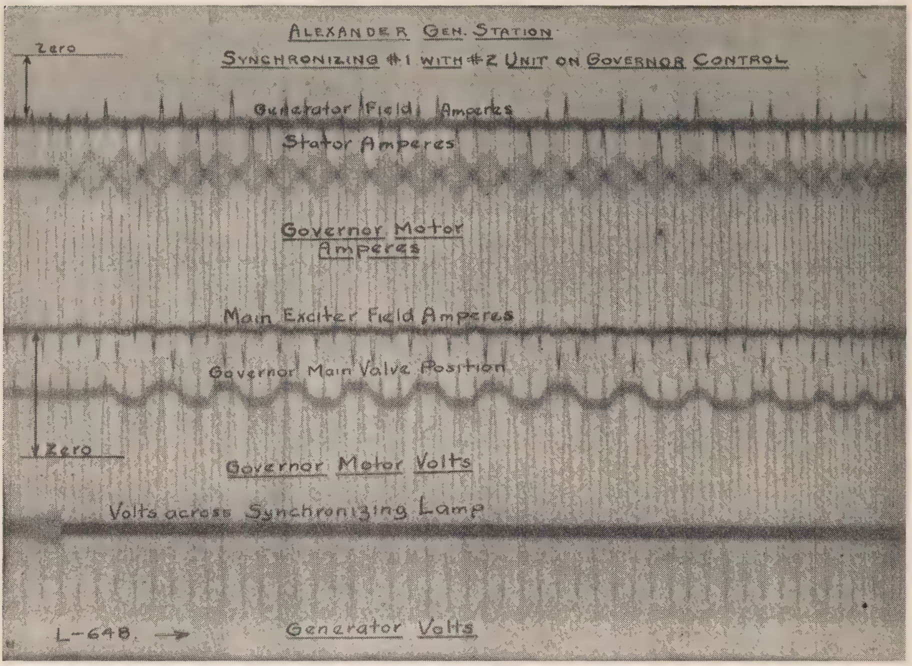


Fig. 3

out after approximately one minute. During this test, the governor valve went through its complete travel and the hunting of the governor motor is indicated by the variation in the motor current.

On oscillogram Fig. 2 it will be noted that the governor main valve commenced to open approximately 1/8 second after the generator was synchronized and continued for approximately 2/3 of a second after the oil circuit breaker had opened and the disturbance removed from the excitation system.

General

The above relating to the pilot exciter drive for governor flyball motors will give an idea of the problems and troubles encountered. The foregoing is meant to be an explanation of the trouble and not to condemn the drive system as a whole. Though a number of successful pilot drive systems were in operation in important plants, prior to the above tests being made, little was really known regarding desirable characteristics of pilot exciter drive in combination with the driving of a speed governor motor until the foregoing troubles developed and were investigated at the Alexander Development.

It is difficult to determine from ordinary design calculations of the generator manufacturers whether or not satisfactory performance will be obtained by the use of a low frequency drive for a governor head motor tapped off the armature of a pilot exciter. The performance is so directly affected by the design and

inherent characteristics of the system network to which the generators are connected, the generator and the excitation system, the flyball motor, the voltage regulator and the sensitivity of the governor.

News of new developments such as the pilot exciter drive system has a tendency to be disseminated rapidly and the idea formed that such a system of drive can be adapted to any unit, based on the fact that the drive system has been found to function satisfactorily on previous installations; such a conclusion should not be accepted for any installation.

It may be found possible to lessen the governor disturbances by various means where trouble is encountered after a plant is completed but same requires careful study as the remedy adopted to curb the disturbance may result in a less sensitive governor.

From results of the tests made, it appears necessary that for this system of drive, the rating of the pilot exciter on a heating basis must be such that it can carry continuously the maximum load it is subjected to. In the design of the pilot exciter, consideration should be given to using a compensating winding and interpoles, the chief objective would be to avoid a flux shift in the pilot exciter under all operating conditions likely to be encountered.

(*Continued in June Issue*)

Electric Eels

Large numbers of people have been turning their footsteps towards the Paris Aquarium at Porte Dorée (in the Colonial Building), where, living in captivity in a large glass tank, are six of the finest specimens of the famous electric eel or Gymnotus Electricus. This paralysing fish (dark blue back with orange belly) is really not a member of the eel family. It is a cat fish and is also related to the carp; it is found only in South American fresh water rivers and ponds. In Brazil it attains the length of six feet, and specimens have been captured that exceed the thickness of a man's thigh. Modern research by Professor D'Arsonval and others has established that the classic descriptions as found in the books of old-time natural history, particularly those of Humboldt, who gathered his electrical information from the natives, are grossly exaggerated.

In truth, the electric eel is the largest and most powerful electric shock-giving creature. It stuns its prey (fish) by administering a powerful electric shock, not by charging the water in the wholesale manner, as was formerly supposed, but by a direct contact shock. At Paris the scientist who conducted me caused some live carp to be placed in the tank with the eels. These were quickly sensed by the eel which although possessing eyes, appear to be blind. As the carp approached the eel, the latter quickly formed a complete circuit across the body of the unfortunate carp by bringing the tail into contact with the carp, which was already in contact with the upper section of the eel. With smaller fish actual double pole contact is unnecessary. The fish are not completely killed at the first contact. Research at Paris by D'Arsonval indicates that the shock would certainly be sufficiently powerful to kill

a mule or a horse (these animals being very easily electrocuted), but not a man. The electric supply runs down quickly after the first discharge but, unless badly exhausted, recuperation takes place rapidly.

ELECTRIC MECHANISM OF THE EEL

Much interest and speculation has always centred around the nature of the eel's electric supply. For a detailed description the reader must consult that of Coldstream in the Encylopaedia of Anatomy and Physiology, and have recourse to the dissected models in the Museum of the Royal College of Surgeons. Briefly, it may be said that the electrical apparatus consists of an organ that extends the whole of the tail-length and comprises some four-fifths of the body. It is composed of two series of cells consisting of vertically placed hexagonal prisms. They consist of nerve fibres divided by transverse partitions, which act as insulators in contrast to the highly conductive nervous tissue. On the average there are 240 of these transverse septa to the inch—a veritable Volta's Pile. The area of the complete electric organ of an eel, such as may be seen in Paris, is about 120 sq. ft. One of the two electric organs is always larger than the other. Both are supplied with unusually large nerve trunks far larger than any that innervate the muscles of the fish. The cells at the two ends of the prisms are in contact with the skin of the eel. The polarity is positive at the tail and negative near the head. This is the reverse of the polarity found in the African and Nile electric fish, as in the latter the current passes from head to tail, according to standard description by naturalists. The current is d.c. and the initial pressure in the large Paris eels is 300 volts. Attached to suitable electrodes a spark can be obtained, water decomposed and, momentarily, a high resistance filament lamp may be raised to incandescence. (D'Arsonval used carbon striplight lamps.)*

Although the electric eel is the most powerful of these creatures, there is a second widely distributed electric fish called the electric ray or numb fish, that is not unlike a skate, only fatter. This fish inhabits the Atlantic and the Mediterranean, and the writer caught one in Sydney, Australia, not long ago. The shock given by the ray is comparatively mild and resembles that obtained from a progressively good contact on about 60 volts d.c. The electric organ is arranged on the same general lines as in the eel, but the cells have only about 100 septa to the inch (in all about 58 sq. ft.) in the largest size. The electric organ (in two sections) is placed between the head and the pectoral fins. The upper surface of the fish is positive in this case.

* One of the most interesting features of the electric eel, which has apparently escaped former observers, is the fact that the fins that run the whole length of the tail ripple in a continuous wave in the direction of the swim of the eel. The reversal of this wave, which is plainly visible, indicates that the eel is about to swim backwards. There seems to be a relation between the agitation of the fins and the administering of the shock.

—HAROLD H. U. CROSS, in *The Electrician.*

Cosmic Rays*

By Dr. Gordon Ferrie Hull, Department of Physics, Dartmouth College, Hanover, N.H.

TO appreciate the story of Cosmic Rays we must go back to the closing years of last century. In those years new realms were opened to physics and all those realms were concerned with rays—streams of energy of some sort moving in straight lines. From a study of the cathode rays came the discovery of the Electron, the unit of electricity, one of the constituents of all atoms; from similar studies came the discovery of X rays; Becquerel rays; radium with its alpha, beta, gamma rays. It may be well in passing to note that no other period in the world's history can compare with the years '95 to '98 in startling, revolutionizing discoveries. These various rays, temporarily tagged with letters from the Roman or Greek alphabet, differed in certain properties but they all possessed a common characteristic, they caused a gas through which they passed to become slightly conducting to electricity. Ordinarily this was made evident by the discharging of an electroscope when a "ray" was allowed to pass between two metal plates one of which was connected to the leaves of the electroscope and the other to earth.

But it had long been known that an electroscope would leak or lose its charge with no known agency operating. This was generally regarded as due to the natural cussedness of electroscopes. Nature abhorred a vacuum and electroscopes abhorred a charge, such were the teachings of the most exact of the exact sciences in earlier years. But the discovery of radium with its enormously active rays brought a new point of view; it suggested that perhaps all matter was radioactive, perhaps there were radioactive particles in the atmosphere. These suppositions turned out to be partly correct but—and here begins the story of the quest of the cause of the penetrating radiation in the atmosphere.

It began in Canada more than thirty years ago. At McGill, Rutherford and Cooke built a brick wall round an electroscope and noted that its rate of leak was less than before. McLennan and Burton at Toronto made a similar observation for an electroscope immersed in a tank of water. McLennan lowered an electroscope about thirty feet below the surface of Toronto Bay at a point where the water was sixty feet deep and found a decrease in rate of discharge. He was afraid to lower it further because he thought that "earth" was radioactive—as it frequently proved to be. These experiments and various others led the Canadian physicists to state that

---

* This article, by Dr. Gordon Ferrie Hull, a graduate of University College, University of Toronto, of the class of 1892, is reprinted from the April 1933 issue of the University of Toronto Monthly. Dr. Hull is at present on the staff of Dartmouth College, Hanover, New Hampshire.

"there is a penetrating radiation in the atmosphere".

Just before the War activity shifted to Europe, chiefly to Germany. There, physicists sent electroscopes up into the air by means of balloons or they themselves went up with the instruments and they made one startling discovery, the activity increased as they got away from the earth. That settled one point—the penetrating radiation, i.e., radiation which could pass through two inches of lead, was not due to radioactive material in the earth nor in the atmosphere. The chase quickened. Observations were made on mountain tops, in valleys, in ice grottos, under the surface of lakes. The data led to numerous articles entitled—Penetrating Radiation of Cosmical Origin. Came the War and, except for some observations in Switzerland, all was quiet on the cosmic front.

After the War Millikan took up the chase. He sent electroscopes up nine miles, higher than they had ever gone, and they returned bringing the complete story of their rate of discharge at various heights. He put them down into lakes, some high up on mountain sides, others in valleys, again deeper than any up to that time had been lowered. He made accurate measurements of the barometric pressure and, reducing his data to make allowance for depth below the top of the atmosphere, he obtained well defined, consistent curves giving the absorption of the radiation due to atmosphere and water. He then attempted to analyze his results and to account for the origin of the rays—but that is another part of the story.

Let us return to consider the properties of the rays referred to in the first paragraph. When cathode rays, streams of negatively electrified particles (electrons) in a vacuum tube, are driven against a target by the applied voltage, X-rays scatter from the target. Now the electrons for ordinary voltages do not have a high penetrating power, they would not in general be able to pass through the glass walls of the tube; but the X-rays produced by them have that power and the greater the voltage applied to the tube the greater the penetration of the X-rays. Hence we speak of X-rays as having an energy of so many electron-volts.* Thus, if we can measure the penetrating power of X-rays we can determine their equivalent voltage. The same is true for the gamma rays from radium. Both of these "rays" are exceedingly short light waves—or are streams of light bullets, *photons* of high energy. The beta rays from radium are like the cathode rays but of greater energy. The alpha rays from radium are helium atoms (positively charged) also of great energy (about six million electron-volts). Streams of electrified particles can be deflected by electric or magnetic fields but X-rays or photon rays cannot be so deflected.

Since Millikan found a trace of cosmic radiation even at a depth of 200 feet of water he inferred that he was dealing with radiation of the X-ray type. Greatly extending the known laws concerning the absorption of those rays, he computed their voltage. He believed that his penetration curve was due to rays of four

* The electron-volt is the energy gained by an electron as it passes through a distance in which the fall of potential is one volt.

different degrees of hardness. The estimated voltages were 26, 100, 160, 350 million volts. When it is stated that the highest voltage X-rays upon which measurements had been made were of a few hundred thousand volts it can be seen that he was not lacking in courage in making his estimate.

How could rays of such energy be produced? Einstein had given a relation which indicated a source. Mass may vanish and take the form of energy. It is then a simple arithmetical problem to find the appropriate mass which "destroyed" would give rays of any desired voltage. It turns out that if four hydrogen atoms unite to form a helium atom the excess mass which would have to be transformed would give a photon of 26 million volts. The other three radiations would arise from the generation of oxygen, magnesium, and iron out of hydrogen. Hence Millikan announced that cosmic rays were generated in the depths of space when certain heavy atoms were created out of hydrogen. The resulting radiation would have to be of the photon or X-ray type. No such phenomenon as the creation of heavy atoms out of hydrogen is known in physics nor is there any physical reason why the phenomenon should take place, but so far as computations on paper are concerned the phenomenon is possible.

Jeans and Eddington also made a proposal. It was that an electron and proton, the constituents of the hydrogen atom, rushed at each other with such violence as to destroy each other as electricity (and therefore as matter) and thus caused their mass to be changed over into radiation—of 940 million volts energy, also of the photon type. Thus there were two opposing views to account for Cosmic Rays, (1) the synthesis of heavy atoms out of hydrogen and (2) the destruction of hydrogen. It will be seen in what follows that neither view, in all probability is correct.

So far experiments having to do with Cosmic Rays were concerned with their penetrating power. New types of experiments were begun in Europe and America to see whether they could be deflected by a magnetic field. These experiments proved that cosmic rays themselves, or secondaries produced by them, were so deflectable and from the curvature produced by the magnetic field the energies of the rays were computed. Energies obtained in this way ran in some cases as high as one thousand million volts. Hence it was seen that Millikan's objection to the destruction-of-hydrogen hypotheses, viz., that it gave energies higher than any indicated by his penetration curves, would have to be withdrawn.

During the past year two entirely different sets of data have been obtained which have greatly enlarged our knowledge of Cosmic Rays. Regener of Stuttgart sent an electroscope down 750 feet below the surface of Lake Constance and up about 28 miles in the air. Thus he extended the down and up data three times as far as those previously known. The high altitude data are not likely to be surpassed since his instrument registered a pressure of only 22 millimeters of mercury. In other words only 3 per cent. of the entire atmosphere was above his instrument, 97 per cent. below. These data showed that the intensity of the penetrating

radiation increased continually with height, curving off towards a constant value as the top of the atmosphere was reached. And this proves that the radiation entering our atmosphere must be largely of the electric bullet nature not, as Millikan assumed, of the photon or X-ray type.

The other set of data has been obtained by A. W. Compton and various men associated with him. They have measured the intensity of the rays at some eighty different stations scattered over the earth's surface, at sea level, on the tops of very high mountains, near the magnetic equator and near the earth's magnetic poles.* These data show clearly that there is a variation in the intensity of the rays which must be caused by the earth's magnetic field. This result supports the view that the rays entering our atmosphere must be of the electric bullet type and the theoretical indications of their energy runs into tens of thousands of millions of volts. When it is said that the General Electric Company has been working for years in an attempt to make an X-ray tube of one million volts (they have reached 750,000) it will be seen that Cosmic Rays are at present of super-human energy.

In my recent lecture before the Royal Canadian Institute I showed an experiment which demonstrated the entrance of an alpha particle (helium nucleus, or positively electrified helium atom) into a small brass cylinder. The polonium, which was the source of the alpha particles, was held about an inch and a half in front of a small hole in the brass cylinder. A metal point inside of the brass cylinder and insulated from it was connected by rather critical resistances and condensers to the grid of an electron tube and the cylinder was connected also by a critical resistance to the ground. When a voltage of about 1,800 volts was applied to the fine point an alpha particle entering the chamber through the hole caused an electrical impulse to be communicated to the electron tube. This was amplified and was announced by the bark of a loud speaker. When a strip of cellophane one thousandth of an inch thick was placed in front of the hole the polonium had to be brought within half an inch of the hole in order for the alpha particles to produce this effect. With two one-thousandths of an inch of cellophane (or mica) in the path the alpha particles could not get through. Now those alpha particles are estimated to have an energy of four million volts yet they will not penetrate one five hundredth of an inch of cellophane. It is obvious that if Cosmic Rays are due to electrically charged atoms these atoms must have energies thousands of times greater than atoms which are ejected by the radioactive elements that we know on the earth.

A somewhat similar experiment was shown for Cosmic Rays. A copper cylinder about two inches in diameter and eight inches long placed inside a glass tube was one terminal of the high potential and a fine wire down the axis of the cylinder was the other. The glass tube was partially exhausted, placed inside of an aluminum

* Unfortunately these data were not secured without human sacrifice. Last May on the Muldrew Glacier of Mount McKinley, two members of our expedition, Allan Carpe and Theodore Koven, fell into a crevasse and perished.

cylinder and connected to a rather elaborate amplifier. A loud speaker connected to the amplifier barked sharply at the rate of about 250 per minute. The sound was the same as that produced by the entrance of an alpha particle into the small cylinder. The phenomenon was obviously due to an electrified particle passing through the chamber formed by the copper cylinder and fine wire. It is easy to show that these "barks" are due almost entirely to Cosmic Rays.

The amplifier was so arranged that two or three chambers could be connected to it but in that case no pulse was communicated to the loud speaker unless all the chambers were disturbed at the same instant. If only two chambers are connected and if they are placed at some distance from each other in a horizontal plane the loud speaker does not bark more than once an hour. But if the chambers are placed one vertically above and only a few inches away from the other the barks occur about fifteen per minute. Here a bark is due to a ray which has passed through both chambers and it is clear that the rays come chiefly from above. The frequency of the barks would depend on the thickness of the roof, floors and walls of the building as well as on the hundred or so miles of air through which the rays would have to pass in order to reach the apparatus.

This method of demonstrating the existence of Cosmic Rays illustrates their enormous penetrating power, brings out their bullet-like nature, and enables one to compute the number per second passing through any area on the earth's surface. There are, for example, about 15,000 rays passing through an average human body per minute, day and night. One cannot easily hide from them.

As it appears highly probable that at least a large fraction of these rays enter the atmosphere as electrified particles the questions arise—what causes them? Where do they come from? What becomes of them? Are there radioactive atoms of very large atomic mass undergoing disintegration thus producing super-mundane beta rays? Or given that there are electrified particles in interstellar space, can these be bombarded by light and thus acquire energies we now attribute to Cosmic Rays? At present a definite answer cannot be given but at least we are able to eliminate any explanation which gives us Cosmic Rays only of the photon type.

I leave to the reader the problem of computing the number of rays entering our atmosphere, striking the surface of the earth, hitting the sun per second or the number in a cubic mile of space. It is obvious that we have discovered a new and exceedingly energetic universe.

Light—the Crime Deterrent

WE recently saw a large collection of clippings taken from newspapers from various parts of the country. Each one of the printed items referred to the action of city authorities in reducing the street lighting budget for the coming year. Many of the editorial comments expressed doubt as to the wisdom of such procedure. Some referred, generally, to the value of street lighting as a crime deterrent, others were more specific in that they quoted police officials as giving a street lamp a value equivalent to one policeman, from a protective standpoint. One paper, probably facetiously, but none the less pertinently, asked the city fathers if they proposed to hire an extra policeman at a cost of $2,000 for each street lamp cut out of service at a saving of $50, thus bringing about a net loss of $1,950 for each lamp for the year. Of course, these comparative values of a policeman and a street lamp as crime deterrents are based on the opinions of police chiefs and police commissioners, and yet no other body of men is so well qualified to give authoritative expression on the subject.

The conduct of the lawless element, as reflected in insurance-company records, substantiates the protective value of light. Fully 75 per cent. of criminal entrances are effected at the rear or sides of business structures and residences where there is little or no illumination. Probably an even greater proportion of night-time hold-ups take place on poorly lighted streets, lanes, alleys, and "short cuts". The common denominator of all these locations is the absence of light.

The aftermath of the so-called "Golden Rule" experiment in one of our midwestern cities, by which the authorities agreed not to molest criminals so long as they refrained from their nefarious practices in that city, contributes another item of evidence as to the protective value of light. Naturally, the city became a haven of refuge for the lawless element. When the agreement was terminated the criminals started an orgy of burglaries and hold-ups of such proportions that for a time the organized forces of law and order were not adequate to meet the situation successfully. Residence owners found that by installing flood-lights about the eaves of their houses (so that electric service could not be discontinued readily), they were made practically immune from burglaries. Likewise, business houses found protection and profit by flood-lighting the rear and exposed sides of their buildings.

According to Mr. Kirk M. Reid, a survey was made in the city of Cleveland to determine the effect of good lighting upon street crimes, such as assaults, automobile thefts, hold-ups, and burglaries. In the year following relighting of a whole district, the street crimes in that district were found to be approximately 40 per

cent. less than they had been during the preceding year.

Ordinarily we do not think of going away for a vacation (or even for an over-night stay), without locking the windows and doors of our homes, and we should be equally cautious when we expect to be absent for no more than an hour or two. Except for the length-of-time element we see no difference in leaving the windows unlocked while away on a two-weeks' vacation, or during a two-hours' visit at the home of a friend or at a movie theatre. Two hours is considerably more time than the average burglar or sneak thief requires to do a thorough job of ransacking.

Locking the doors and windows will often prevent entrance by unauthorized persons, and will always make such entrance more difficult. If, in addition, the house owner who goes out for an evening, would leave at least one room well lighted, he would thereby materially increase his protection. A lighted house, lacking definite knowledge to the contrary, is usually assumed to be occupied; and presumably the occupants are awake and therefore likely to hear the noise made by anyone trying to enter. The cost of such lighting would be on the order of five or ten cents for the whole evening—an insignificant sum compared with the protection afforded.

We have seen estimates ranging from thirty million dollars to one hundred million dollars, as the yearly loss resulting from crimes committed under cover of darkness. We suspect (without having any definite information) that the larger figure is more nearly correct. Certainly, the American public could well afford to spend this sum to bring about an increase in the area of well-lighted sections of cities and towns. The greater the well-lighted area in a city, the more restricted is the region in which the criminal can operate easily and successfully. Just as his field of operation is thus limited, so also is the area to be watched by the police reduced, with the result that the officers can give more attention to this area. All of this simply means that darkness is the silent partner of the criminal; light is his ever-vigilant opponent.

—*The Travellers Standard.*

Hydro-Electric Power Commission of Ontario

Free Flat Rate Water Heater Plan Means Work and Wages

THE plan of the Hydro-Electric Power Commission of Ontario to install free electric flat rate water heaters in Hydro homes throughout the Province is based on months of study and investigation by Hydro engineers. The result is that the type of equipment being installed can be adjusted to meet the requirements of any sized home or family.

As the plan now stands, it is the first development of its kind ever undertaken by any public or private utility—a development which makes easily available to Hydro users a complete and satisfactory hot water service—automatic, trouble-free and far more economical than any other comparable means of water heating.

The co-operation of Ontario manufacturers and contractors in this Hydro enterprise will result in a long needed stimulus to work and industry in the Province. Heaters and equipment used in their installation will be manufactured in Ontario factories. The heaters will be installed by Ontario workmen in the electrical, mechanical and allied trades. And in every phase of work and installation involved, contractors and their workmen will be awarded fair and equitable remuneration.

Every manufacturer and contractor will grasp the significance of this Hydro plan which has already influenced industry and wages in Ontario. Wheels that have been idle now turn again. Men unemployed for months are now at work. And through the letting of contracts, the disbursement of wages and the continuous revenue from Hydro users for water heating, a constantly revolving fund of money will be set in motion, benefitting employers, wage-earners and homes throughout Ontario.

HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO

THE BULLETIN

Published by

HYDRO-ELECTRIC POWER COMMISSION of Ontario

620 University Ave. Toronto

Subscription Price $2.00 Per Year

The New Home of Hydro in Toronto

IT would seem most fitting that a new head office building should be occupied by the Toronto Hydro-Electric System only shortly after the coming of age of Hydro in Toronto. For the building is not only a symbol of achievement but is also a welcome release from the inconveniences and inefficiencies resulting from the somewhat inadequate accommodation possible during the period of rapid expansion of the past twenty-two years.

Beginning in a modest way in an upper room in the City Hall, June 1, 1911, the administrative branch of the System had grown until, just prior to removal to the new building, something like 800 executives and employees were housed in four separate offices, two of which formed portions of sub-station properties, the other two being in non-fireproof buildings antiquated and unsuited to the requirements of modern business efficiency.

Two stores were also operated. One of these was a heritage from the Toronto Electric Light Company, the other was leasehold property. Both were lacking in the dignified appearance necessary to the display of modern merchandise.

Generally speaking, one might say that the architecture of the new building betrays the modern touch without being in the least degree extreme or modernistic. The exterior walls are of Queenston limestone on a granite plinth. The front elevation above the mezzanine floor level is pilastered with spandrel sections set back and with integral provision for future floodlighting. Show windows, the main and administrative entrances are in bronze, while in the main store—consisting of a large central area surrounded by a mezzanine floor—monel metal and bronze have been freely used in railings, doorways and screens. A judicious use of marble, together with the gray and buff treatment of the plaster work, results in a very attractive interior.

It is especially noticeable that the convenience of the general public has been given every attention in the lay-out of the public spaces. The customer or others having business

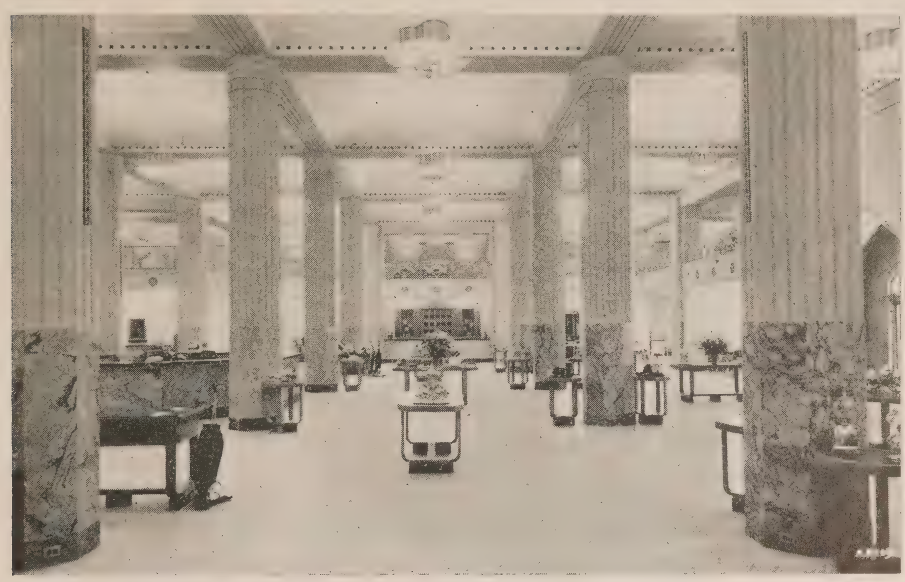
CONTENTS

Vol. XX No. 6
June, 1933

with the System on entering the store are immediately aware of the information desk set in the form of an octagonal island in the rear centre of the floor. Here all inquiries are made, duplicate bills are received and any necessary arrangements made for interviews with personnel. Cashiers' wickets, the repair counter, the Home Institute and other departments with which the public have much to do are likewise immediately accessible.

All floors are occupied and comparatively little space is available for any large scale expansion. However, adequate provision has been made for any possible future requirements. Column steel and footings are in for a tower over the central portion of the building and provision has been made for an extension to the rear. No attempt has been made to decorate the office portion of the building in any elaborate fashion. The floors are linoleum laid on hollow tile and concrete; the walls and ceiling are plastered and painted, being furred down only where necessary to conceal piping or other services. Attention

Toronto Hydro Shop, viewed from main entrance.



Another view of Toronto Hydro Shop.

has been paid, however, to securing the maximum possible degree of comfort through adequate lighting, both natural and artificial, ventilation and heating.

This building is one of the most up-to-date of any in Canada in respect to its electrical equipment. It is supplied from the System's low-voltage a.c. network, a transformer vault being located immediately outside in the sidewalk area. Provision has been made throughout for high intensity illumination; the vertical bus system of distribution is used, together with column breakers controlling local circuits. An extensive underfloor duct system for both telephone, signal and power circuits has been installed.

The mechanical equipment calls for little comment except to mention that the store area is supplied with conditioned air, city water being used during the summer months for dehumidification and temperature control.

Construction was commenced during the worst period of the depression and gave work to many of the trades most hardly hit by unemployment. Thus, the project was one of the most important of the relief works undertaken in the city of Toronto. Not only so, but the Toronto Hydro-Electric System now possesses a building of excellent construction and appearance, built at a very substantial saving over peak costs.

It is hardly necessary to say that Canadian or Empire products were given preference wherever possible.

Preliminary plans and office layouts were prepared by the System's own architectural staff, these forming the basis for the final plans prepared by Messrs. Chapman and Oxley, Architects. Structural design was

carried out by Messrs. Harkness and Hertzberg, Engineers. The mechanical plant was designed by Harry H. Angus, Engineer, while the electrical equipment was designed by the McMaster-Jacob Engineering Company. The general contract was awarded to A. W. Robertson Limited. The location and plans were approved not only by the Toronto Electric Commissioners but also by the City Council and the Hydro-Electric Power Commission of Ontario.

The Toronto Hydro-Electric Commissioners are Joseph Gibbons, Chairman, William J. Stewart, Commissioner and Mayor, and Loftus H. Reid, Commissioner. E. M. Ashworth is General Manager. They are to be complimented on having erected a building that is a credit to not only the City of Toronto and the Toronto Hydro-Electric System, but also to Hydro throughout Ontario.

Chairman, The Honourable J. R. Cooke's Letter of Submittal of the Twenty-Fifth Annual Report

TO HIS HONOUR THE HONOURABLE HERBERT A. BRUCE, R.A.M.C., M.D., F.R.C.S., *Lieutenant-Governor of Ontario.*

MAY IT PLEASE YOUR HONOUR:

The undersigned has the honour to present to your Honour the Twenty-fifth Annual Report of The Hydro-Electric Power Commission of Ontario for the fiscal year ending October 31, 1932.

This Report covers all of the Commission's activities and also embodies the financial statements for the calendar year 1932, of the municipal electric utilities operating in conjunction with the various systems of the Commission and supplying electrical service to the citizens of the Province.

Dealing, as it does, with a multiplicity of activities relating to several electrical systems obtaining power from thirty-eight hydro-electrical developments operated by the Commission, supplemented by power purchased from other sources, and recording financial and other data relating to the individual local municipal electric utilities, the Annual Report presents a large amount of statistical information, much of which must, of necessity, be of a summary character.

The financial statements, the statistical data and the general information given, however, are so arranged and presented as to give a comprehensive survey of the Commission's operations. Not only does the Report record the progress made during the past year, but it gives, in addition, certain cumulative results for the various periods during which operation has been maintained in the respective municipalities.

At the end of the fiscal year the

number of municipalities served in Ontario by the Commission was 747. This number included 27 cities, 95 towns, 267 villages and police villages and 358 townships. With the exception of 13 suburban sections of townships known as voted areas, the townships and 88 of the smaller villages are served as parts of 172 rural power districts.

Constructional Activities

Constructional activities during 1932 were limited in scope, and consequently capital outlays by the Commission were much reduced. The chief work undertaken was the completion of the Chats Falls development on the Ottawa River, to the stage at present decided upon. Eight turbines are now installed. The present normal capacity of the development is 192,000 horsepower—half of which is owned by the Commission and half by the Ottawa Valley Power Company in the Province of Quebec.

At the Commission's transformer station at Chats Falls the third and fourth banks of transformers were installed providing for a total output of 188,400 kv-a. A 220,000-volt transmission line 100 miles long similar to the other 220,000-volt lines built by the Commission was constructed from Beaudet on the Ontario-Quebec boundary to Chats Falls, to transmit the power being received from the Beauharnois development on the St. Lawrence River. At Cumberland, on this transmission line, about 45 miles from Chats Falls, a switching station has been provided to form a junction point for a transmission line being constructed from the MacLaren power site on the Liévre River.

It will thus be seen that Chats Falls has become an important power supply centre. Power is assembled here from the development at Chats Falls and from Beauharnois, and in the near future supplies of power will also come from the MacLaren development. In addition, of course, power supplies from the Gatineau River plants cross the Ottawa River at this point.

In the Niagara district at Queenston the temporary wooden bridge, which carried Queen street over the railway which serves the Queenston generating station, was replaced by a new steel bridge. At the village of Chippawa a new approach span for the highway bridge crossing the Welland River was erected.

Throughout the several systems changes and improvements are constantly being made with a view to the maintenance of equipment at high efficiency. In this connection special attention continues to be given to the problem of protection by high-speed relays and other special devices.

Operating Conditions

During the past year the quality of service rendered throughout the several systems and districts was generally satisfactory. Interruptions were few in number and most of those that did occur affected relatively small areas. No serious failures of equipment occurred.

In those districts where the water supply is an important operating feature, notably those served by the Georgian Bay, Eastern Ontario and Thunder Bay systems, the amount and seasonal distribution of the flow of the various rivers were very

favourable during the year; more so than for several years past.

Among the new developments in operating equipment may be mentioned the new permanent-magnet generator installed for governor drive on one of the units at Alexander. This is the first governor drive of this type to be used. It has proved very satisfactory and represents a distinct advance in engineering design. The automatic synchronizing equipment installed at the same station is the first installation of equipment of this nature in any station of the Commission and one of the first installations anywhere on generators of such large size. Supervisory equipment for remote control at Alexander generating station was put into service during the year. This is one of the largest stations in which such automatic control equipment has been installed up to the present time. Throughout the systems generally the special attention given to high-speed relay protection has improved service and given additional protection to equipment. Details of this and other operating features are given in the body of this report.

In connection with the operation of its transmission and distribution lines the Commission maintains a Forestry division with an expert field staff. The work of this staff has met with very favourable reception from property owners and public officials. During the year more than 46,000 trees were pruned, cabled or removed at an average overall cost of $1.85 per tree.

Cost of Electrical Service Furnished by the Commission

The function of the Commission is not only to use its best endeavours to provide for the people of Ontario an adequate and reliable supply of electrical energy, but also to ensure that the cost of that electrical energy to the consumers shall be the minimum consistent with the financial stability of the enterprise. The success that has been attained in the accomplishment of the latter object may be appreciated by a careful study of the actual rates to consumers as presented in Statement "E", and of the statistical data setting forth the results that have been attained for the consumers under these rates, as presented in Statement "D," in conjunction with the various financial statements of the Report.

The bill for retail service rendered, is the practical aspect of Hydro service with which the average consumer is most concerned. It is, therefore, a satisfaction to note that except in a very few cases the rates for service during the period of depression have been maintained at their low levels or have been made lower.

The knowledge that there are substantial reserves of power which can be distributed at low cost is a distinct encouragement to the industrial organizations of the Province. Moreover, notwithstanding the generous use made of electrical service by the domestic and rural consumers in Ontario, there is still a large potential market for numbers of electrical appliances which the low cost of electricity makes it economically practicable to

use. In this connection the Commission is inaugurating a campaign for the greater use of domestic hot-water heaters.

LOAD CONDITIONS

The demand for power in Ontario has continued at approximately the same levels as during the previous year.

It has been the custom to show at this place in the Annual Report the total loads for October and December of the current and previous years. Conforming with last year's Report, and for reasons fully stated therein, the following figures (Table I.) are first presented relating to Canadian load only, that is, exclusive of export power.

December, which are presented in the table above, show an increase.

As special publicity has been given to the effect of the business depression on power sales, it is appropriate to call attention to the fact that the Commission is selling more power and operating more power stations and transmission lines than it did in 1928, the year before the depression started. The depression has had, of course, a marked effect on the sale of power. A substantial proportion of the industrial plant of Ontario is at present idle, or working far below its capacity, and power temporarily discontinued in respect of such industrial plant has not been entirely absorbed by the continued growth of domestic and certain other demands. The net result has been to postpone the substantial increases in total load that otherwise would have occurred in these years.

TABLE I.

	October 1931	December 1931	October 1932	December 1932
Niagara system (Canadian load only)	756,032	775,180	789,008	786,059
Other systems, total	245,273	253,114	239,438	251,898
Grand total (Canadian loads only)	1,001,305	1,028,294	1,028,446	1,037,957

It will be noted that the figures for the current year show a slight increase over the previous year. Comparing figures for the complete fiscal years of 1932 and 1931, the average load of all systems in Ontario shows a slight decrease, amounting to 1½ per cent. A slight improvement in conditions towards the end of the year may be inferred from the fact that, although the average load for the entire fiscal year decreased slightly, the loads for October and

The following tabulation (Table II) corresponds to that given for several years in this place in the Report and shows the power supplies to the various systems at the close of the year including, in the case of the Niagara system and of the grand total, export power as well as power for Canadian use. The lessened

TABLE II.

DISTRIBUTION OF POWER TO SYSTEMS

20-Minute Peak Horsepower System Coincident Peak

System	October 1931	December 1931	October 1932	December 1932
Niagara system	805,630	828,200	839,946	838,338
Dominion Power & Trans. system	48,659	56,166	43,968	48,525
Georgian Bay system	26,356	27,531	25,666	26,424
Eastern Ontario system*	85,857	91,253	80,544	86,716
Thunder Bay system	51,600	50,300	65,700	63,800
Northern Ontario system:				
Sudbury and Abitibi districts	27,200	21,850	17,761	20,576
Nispissing district	3,689	4,088	3,751	3,799
Patricia district	1,912	1,926	2,048	2,058
Totals	1,050,903	1,081,314	1,079,384	1,090,236

* Eastern Ontario system includes Central Ontario, St. Lawrence, Rideau, Ottawa and Madawaska districts.

industrial activity has continued to curtail the market for surplus power. Apart from its export of power under the firm power contracts acquired by the Commission in its purchase of the Ontario Power Company, there has been practically no export of power during the past two years.

Financial Summaries

The financial statements embodied in this Report are presented in two main divisions, namely, a division—Section IX—which deals chiefly with the operations of the Commission in the generation, transformation and transmission of electrical energy to the co-operating municipalities; and a division—Section X—which deals with the various operations of the municipal electric utilities in the localized distribution of electrical energy to consumers. In Section IX, "Rural Operating" reports are also given, which summarize the results of the local distribution of rural electrical service by the Commission to the individual consumers in rural power districts. This work is performed by the Commission on behalf of the respective townships co-operating to provide rural service.

The cumulative results of the operation of the several systems of the Commission as set forth in this Report demonstrate a sound financial condition.

Capital Investment

The total investment of the Hydro-Electric Power Commission of Ontario in power undertakings and hydro-electric railways is $273,248,-829.59, exclusive of government grants in respect of construction of rural power districts' lines; and the investment of the municipalities in distributing systems and other assets is $109,309,934.16, making in power and hydro-electric railway undertakings a total investment of $382,-558,763.75.

The following statement (Table III) shows the capital invested in the

TABLE III.

Niagara system	$202,098,894.93
Chats Falls development	5,878,493.70
Georgian Bay system	8,329,025.78
Eastern Ontario system (including Nipissing district)	21,060,823.96
Thunder Bay system	18,480,738.51
Northern Ontario Districts (including the Generating Plants, Transmission Lines and Transformer Stations in the Sudbury, Patricia and Abitibi Districts)	10,786,686.10
Hydro-Electric railways	1,985,113.20
Office and service buildings, construction plant, inventories, etc.	4,629,053.41
	$273,248,829.59
Municipalities distributing systems and other assets (exclusive of $23,066,129.81 of municipal sinking fund equity in H.E.P.C. system)—all systems	109,309,934.16
	$382,558,763.75

respective systems, districts and municipal undertakings.

REVENUE OF COMMISSION

The revenue of the Commission derivable from the municipal utilities operating under cost contracts and from other customers with whom—on behalf of the municipalities—the Commission has special contracts, all within the Niagara, Georgian Bay, Eastern Ontario and Thunder Bay systems, aggregates $28,055,895.46.

The following statement (Table IV) shows how this revenue has been appropriated:

In connection with the foregoing statement it should be noted that, in making its annual determinations of costs chargeable for power supplied to the participating municipalities, the Commission for many years has followed a policy which recognizes the desirability of stabilizing the costs per horsepower one year with another. Commencing with 1926 and continuing to 1930, there were included in the amounts set aside to the reserve for obsolescence and contingencies, additional sums designed to care for possible lean years that might come

TABLE IV.

Revenue from municipal electric utilities and other power customers		$28,055,895.46
Operation, maintenance, administration, interest and other current expenses	$25,968,030.62	
Reserves for sinking fund, renewals, contingencies and obsolescence provided in the year	4,666,229.51	
	$30,634,260.13	
LESS. Appropriated from obsolescence and contingencies reserves	2,668,147.78	
		27,946,112.35
Net balance credited to municipalities under cost contracts		$109,783.11

in the future. A proportion of these extra reserves was derived from the sale of surplus power. In 1932 the contingency reserve was drawn upon in the case of the Niagara system to the extent of $2,544,648.63, and the similar reserve in respect of the Thunder Bay system was drawn upon to the extent of $143,499.15. This relief was given to the municipalities in their cost of power to compensate for the increased costs and reduced revenues in the year. In all other respects the various reserves have continued to be accumulated on the same basis as formerly, with the result that in the aggregate the reserves of the Commission show a net increase for 1932 of $3,741,074.72 as compared with the totals at the end of 1931.

Rural Electrical Service

During the past few years very substantial progress has been made in Ontario in the field of rural electrification. Practically all rural electrical service is now given through rural power districts which are operated directly by the Commission. There is now rather more than $16,964,000 invested in the rural power district systems established by the Commission. Towards this rural work the Ontario Government, pursuant to its policy of promoting the basic industry of agriculture, has, in the form of grants-in-aid, contributed 50 per cent. of the costs of transmission lines and equipment, or some $8,393,000. A total of 8,918 miles of transmission lines have been constructed to date, of which 721 miles were constructed during the past year. There are now more than 60,000 customers supplied in the rural power districts.

Municipal Electric Utilities

The following (Table VI) is a summation of the year's operation of the local electric utilities conducted by

TABLE V.

RURAL POWER DISTRICTS—OPERATIONS FOR THE YEAR 1932

	Niagara system	Georgian Bay system	Eastern Ontario system	Thunder Bay system	Totals
	$ c.	$ c.	$ c.	$ c.	$ c.
Cost of power as provided to be paid under Power Commission Act	793,950.49	100,332.42	183,372.39	547.62	1,078,202.92
Cost of operation, maintenance and administration	546,720.01	49,909.36	118,744.58	412.59	715,786.54
Interest	290,757.17	34,832.21	72,097.43	368.45	398,055.26
Renewals	236,925.30	26,145.83	59,621.00	264.72	322,956.85
Obsolescence and contingencies	118,462.65	26,145.83	29,810.50	132.36	174,551.34
Sinking Fund	63,315.62	7,237.63	16,015.88	69.69	86,638.82
Total expenses	2,050,131.24	244,603.28	479,661.78	1,795.43	2,776,191.73
Revenue from customers	2,070,703.84	215,718.07	464,258.52	1,672.97	2,752,353.40
Net surplus, all districts	20,572.60	....	....	......	20,572.60
Net deficit, all districts	....	28,885.21	15,403.26	122.46	44,410.93
Net deficit, all systems	....	....	....	......	$23,838.33

TABLE VI.

Total revenue collected by the municipal electric utilities....		$31,216,210.12
Cost of power............................	$19,109,036.25	
Operation, maintenance and administration...	5,492,591.38	
Interest..................................	2,532,940.93	
Sinking fund and principal payment on debentures...........................	2,244,367.86	
		29,378,936.42
Amount available and set aside for depreciation and other reserve purposes..................................		$1,837,273.70

municipalities receiving power under cost contracts with the Commission.

The setting-up of the reserves on rates customarily adopted in the past would have required an amount of $1,920,896.22, which is $83,622.52 in excess of the amount shown in the foregoing table as available for the present year. In this connection it is important to note that the municipal Hydro utilities provide for the retirement of their capital liabilities by either the instalment or sinking-fund method, and such payments are treated as part of the cost of the service.

Reserves of Commission and Municipal Electric Utilities

The total reserves of the Commission and the municipal electric utilities for sinking fund, renewals, contingencies and insurance purposes amount to $122,770,103.91 made up as follows (Table VII).

As has been commented above in connection with the statement of revenues, the total reserves of the Commission increased in 1932 by $3,741,074.72 over the total for 1931, which was $62,404,411.89. The fact that the net increase in total reserves was, in 1932, less than in some

TABLE VII.

Niagara system..	$50,900,344.13
Georgian Bay system..................................	2,482,836.51
Eastern Ontario system...............................	5,228,590.62
Thunder Bay system...................................	2,739,224.49
Northern Ontario districts—Sudbury and Patricia..........	164,783.67
Service building and equipment.......................	664,713.82
Bonnechere storage...................................	1,733.81
Hydro-Electric Railways (Guelph).....................	109,240.31
Insurance, workmen's compensation and staff pensions......	3,854,019.25
Total reserves of the Commission..................	$66,145,486.61
Total reserves of municipal electric utilities..........	56,624,617.30
Total Commission and municipal reserves....	$122,770,103.91

former years, reflects the advantageous working out of the Commission's policy of cost stabilization, under which withdrawals were made in 1932 from special reserves provided out of revenues of earlier years for that purpose. The net increase in the total of Commission and municipal reserves for the year was $7,130,377.53.

The consolidated balance sheet of the municipal electric utilities, on page 262, shows a total cash balance of $3,185,442.00, and bonds and other investments of $2,059,325.10. The total surplus in the municipal books now amounts to $39,820,131.64 in addition to depreciation and sundry other reserves aggregating $16,804,-485.66; these two amounts making the total of $56,624,617.30 shown in the above table.

* * * *

The following is a brief summary of the principal operations relating to the several systems of the Commission:

Niagara System

The Niagara system embraces all territory lying between Niagara Falls, Hamilton and Toronto on the east and Windsor, Sarnia and Goderich on the west served with electrical energy generated at plants on the Niagara River, supplemented with purchased power transmitted from plants on the Gatineau, St. Lawrence and Ottawa Rivers. A few municipalities and districts of the Niagara system are served also with power developed at DeCew Falls.

Power as supplied to the Commission by the Gatineau Power Company is received by the Commission at the interprovincial boundary on the Ottawa River and is transmitted over two 220,000-volt steel-tower transmission lines to Leaside. Power obtained from Chats Falls development on the Ottawa River, which plant was constructed jointly by the Commission and the Ottawa Valley Power Company, formerly the Chats Falls Power Company, is transmitted from Chats Falls to Leaside over a third 220,000-volt steel-tower line.

Arrangements for progressive delivery of increased quantities of power, made some years ago, will furnish power supplies for this system, which, with a moderately rapid return to normal business conditions, should be adequate for the immediate future. In addition to power contracted for with the Gatineau Power Company and power obtained from the development at Chats Falls, which provides the Commission with 192,000 horsepower, the Commission holds contracts for the delivery of additional power, amounting eventually to 250,000 horsepower, to be developed on the St. Lawrence River by the Beauharnois Light, Heat & Power Company, and 125,000 horsepower to be delivered to the Commission as required from a plant on the Liévre River under a contract with the James MacLaren Company Limited, subsequently assigned to a subsidiary power company known as MacLaren-Quebec Power Company. Commencing in October, 1932, the first block of 35,000 horsepower was taken under the contract with the Beauharnois Light, Heat & Power Company.

The undertakings and companies of the Dominion Power & Transmission Company Limited which were

purchased in 1930 have been operated since November 1, 1931, as part of the Niagara system. An agreement was entered into with the Hamilton Hydro-Electric System and the Brantford Hydro-Electric System, by which the Commission sold the distribution systems, substations and other properties in these cities.

The total capital invested by the Commission on behalf of the co-operating municipalities of the Niagara system amounts to $207,977,388.63. This amount includes the investment in the power properties purchased from the Dominion Power and Transmission Company (which have been merged with, and now form part of the Niagara system), also the Commission's share of the generating plant at Chats Falls, together with the transformer and switching stations at that point and the transmission lines from the Ottawa River to the Niagara system. The accumulated reserves for renewals, obsolescence, contingencies and sinking fund, aggregate $50,900,344.13.

From the rural power districts of this system, which are directly operated by the Commission, the revenue received for the year from customers was $2,070,703.84, and the total cost of supplying the service was $2,050,131.24, leaving a balance of $20,572.60, which is placed to the credit of districts in this system.

With respect to the electric utilities of the various urban municipalities of the Niagara system, the cost of power, as adjusted by the Commission at the close of the year was $208,934.39 less than the total amount collected at the interim rates and this sum has been credited to the municipal utilities. The total revenue of the municipal electric utilities served by this system was $25,499,082.64.

After meeting all expenses in respect of operation—including interest—setting up the usual standard depreciation reserve (which amounted to $1,594,493.31) and providing $2,037,378.48 for the retirement of instalment and sinking-fund debentures, the total net shortage for the year for the municipal electric utilities served by the Niagara system amounted to $216,354.05.

Georgian Bay System

The territory served by the Georgian Bay system includes that portion of the Province adjacent to Georgian Bay and Lake Simcoe. The area extends from Huntsville in the north to Port Perry in the southeast, and on the west and north it is bounded by Lake Huron and Georgian Bay. It thus takes in the counties of Bruce, Grey, Dufferin, and Simcoe, and the northern portions of the counties of Huron, Wellington and Ontario, as well as a large portion of the district of Muskoka.

During the year the properties of the Mildmay Electric Company and the Formosa Electric Light Company were purchased by the Commission and merged with the Georgian Bay system. By this arrangement the last of the districts directly, or indirectly, connected with the W. B. Foshay Company's operations in Bruce County have been taken over by the Commission and the entire area in Bruce County consolidated with the Georgian Bay system.

Electrical energy is obtained from eleven hydro-electric generating

plants, three of which are situated on the south branch of the Muskoka River, two on the Muskoka River at Bala, two on the Severn River, one on the Beaver River, and three on the Saugeen River, supplemented by power from the Niagara system through frequency changer stations at Hanover and Mount Forest.

The demands of the various municipalities throughout the year remained practically the same as in the previous year; an expansion, however, took place in rural power districts, both in the area served and in the number of consumers in existing districts. The increase in the system demand over the previous year is almost entirely due to these conditions.

As this was a good water year there was a surplus of water at all plants, and ample capacity was available for supplying the additional power demand.

The total capital invested by the Commission on behalf of the co-operating municipalities of the Georgian Bay system is $8,329,025.78, and the accumulated reserves for renewals, obsolescence, contingencies, and sinking fund aggregate $2,482,836.51.

The revenue received for the year from customers in rural power districts of this system which are directly operated by the Commission was $215,718.07, and the total cost of supplying service was $244,603.28, leaving a balance of $28,885.21, which has been charged to districts in this system.

With respect to the electric utilities of the various urban municipalities of the Georgian Bay system, the actual cost of power supplied by the Commission for the year was $10,546.19 less than the total amount collected at the interim rates. This sum has been credited to the municipalities operating under cost contracts. The total revenue of the municipal electric utilities served by this system was $1,153,622.31, an increase of $38,419.49 over the previous year.

After meeting all expenses in respect of operation—including interest—setting up the usual standard depreciation reserve (which amounted to $68,893.47) and providing $57,236.15 for the retirement of instalment and sinking-fund debentures, the total net shortage for the year for the municipal electric utilities served by the Georgian Bay system amounted to $47,082.77.

Eastern Ontario System

This system serves that part of Ontario lying east of the areas served by the Georgian Bay and Niagara systems. The districts included are the Central Ontario, St. Lawrence, Rideau, Ottawa and Madawaska.

Power is supplied from developments owned by the Commission on the Trent Canal system and the Mississippi and Madawaska Rivers. Power is purchased from the Gatineau Power Company, the Cedar Rapids Transmission Company, the Rideau Power Company, the Corporation of Campbellford and the Beach estate at Iroquois. No major changes were made in generation or transmission facilities during the year.

The corporation of Trenton purchased the local electric distribution system, and the corporation of Cobourg purchased the local electric distribution system and waterworks

from the Commission. The purchases were made on the basis of the Commission's book value of the plants less accumulated renewal reserves. These municipalities entered into contracts for the purchase of power at cost from the Commission.

All the municipal distribution properties forming part of the Electric Power Company property have now been sold to the municipalities concerned, except the plants in Millbrook, Newburgh, Newcastle and Orono, and the gas plant in Cobourg.

The power demands of this system have not changed materially from the previous year and all demands for power by municipalities and customers of the Commission were met without difficulty from the generating plants and purchased supply.

The total capital invested by the Commission on behalf of the co-operating municipalities of the Eastern Ontario system is $21,060,823.96, and the accumulated reserves for renewals, obsolescence, contingencies and sinking fund aggregate $5,228,-590.62.

In the rural power districts of this system, which are directly operated by the Commission, the revenue received for the year from customers was $464,258.52, and the total cost of supplying the service was $479,-661.78, leaving a balance of $15,403.-26, which was charged to the districts in this system.

With respect to the electric utilities of the various urban municipalities of the Eastern Ontario system operating under cost contracts the actual cost of power supplied by the Commission during the year was $40,705.28 less than the total amount collected at the interim rates and this has been credited to the municipal utilities. The total revenue of the municipal electric utilities served by this system was $3,178,756.25, an increase of $294,978.63.

After meeting all expenses in respect of operation—including interest—setting up the usual standard depreciation reserve (which amounted to $211,657.36) and providing $127,-831.33 for the retirement of instalment and sinking-fund debentures, the total net surplus for the year for the municipal electric utilities served by the Eastern Ontario system amounted to $162,022.56.

Thunder Bay System

The Thunder Bay system serves a portion of the district of Thunder Bay, more especially the area lying between the international boundary and Lake Nipigon. Power is secured from two hydro-electric developments on the Nipigon River, one at Cameron Falls and the other at Alexander, and is utilized largely in connection with the pulp and paper industry and the grain trade. Both of these industries are still suffering on account of the world-wide trade depression The total system demand for the year was slightly less than that of the previous year; there is, however, some indication of an early improvement. Negotiations are being carried on for the sale of a substantial amount of power in connection with electric steam generation in the pulp and paper industry.

The Commission has, in the Thunder Bay system, a total investment of $18,480,738.51, and accumulated reserves for renewals, contingencies, and

sinking fund aggregate $2,739,-224.49.

The cost of power to this system as adjusted by the Commission at the close of the year was $126,564.42 in excess of revenue from the interim monthly billing, which sum has been charged to the municipalities operating under cost contracts. The total revenue of the municipal electric utilities in this system was $1,384,748.92. The three municipalities served by this system operated with a net surplus of $17,791.80, after providing depreciation and other reserves to the extent of $45,852.08 and $21,921.90 for the retirement of debentures.

Northern Ontario System

This system covers all of that portion of the Province lying north of the French River and Lake Nipissing, and west of the Quebec boundary, with the exception of the area served by the Thunder Bay system. The active districts in the Northern Ontario system served direct by the Commission are the Nipissing district, the Sudbury district, the Abitibi district, the Manitoulin district and the Patricia district. It should be understood that these districts are not interconnected as are the districts of other systems.

In certain sections of the area embraced by the Northern Ontario system there are independent municipal utilities; engineering assistance and advice concerning the operation and maintenance of these utilities is given by the Commission when requested.

Nipissing District

This district serves the area adjacent to the eastern shores of Lake Nipissing, and includes the city of North Bay, the villages of Callander and Powassan, and the North Bay and the Powassan rural power districts, which latter consist of portions of the townships of Ferris, Himsworth, Nipissing and Widdifield. Power is obtained from three hydro-electric developments on the South River and this supply is supplemented when necessary by power purchased from The Abitibi Power and Paper Co.'s development at Crystal Falls on the Sturgeon River.

The generated peak and average loads on this district show very little change from last year, being higher for some months than for the corresponding months of the previous year, and lower for other months. Over the entire year there were slight increases in both peak and average generated loads.

For the purpose of financial administration the Nipissing district of the Northern Ontario system is associated with the districts of the Eastern Ontario system.

Sudbury District

The active area in this district lies in and adjacent to the city of Sudbury. Power is derived from three developments on the Wanapitei River, and is supplied largely to the city of Sudbury and to various mining companies at 60 cycles only There has been a manifestation of activity in rural districts adjacent to Sudbury throughout the year and the Commission has given assistance and information to the various communities concerning the possibilities of obtaining hydro-electric service.

A general decrease in load has been

experienced in this district during the year. A very small portion of this decrease is due to reduced domestic consumption, the major portion being due to the lessened activities of most of the industrial customers in the mining and smelting industry. As a large portion of the decrease is paid for under the minimum clauses of the power contracts, revenues have not been as adversely affected as load conditions would indicate.

Abitibi District

This district comprises the area within transmission distance of the transmission line between Hunta and Sudbury. Up to October 1, 1932, power was obtained under a contract entered into by the Commission with The Ontario Power Service Corporation Limited, and after October 1, from the Abitibi Power & Paper Company. Power is supplied to mining companies at 25 cycles only.

The operation of the 189 miles of 110,000-volt steel-tower line between Hunta and Copper Cliff was satisfactory throughout the year. Up to the end of the fiscal year, this line comprises all of the Commission's property in this district.

Patricia District

This district comprises the territory adjacent to the Ear Falls development at the foot of Lac Seul on the English River and power is being supplied at the present time to a large gold mine in the Red Lake mining area. Power is available in this district for mining or other purposes when requirements lie within reasonable transmission distance of the development.

The generating and transformer station at Ear Falls have been in satisfactory operation throughout the year. All equipment has functioned as required, there being no failure of major importance. The load on the system has shown an increase over that existing during the previous year, the average monthly energy generated being about 29 per cent. greater and the average monthly peak being about 17 per cent. greater during 1932 than in 1931.

The 44,000-volt transmission line between the generating station and the Howey gold mine, which is owned by the Howey Gold Mines, Limited, has been operated and maintained for them throughout the year under the same arrangement as in previous years. This transmission circuit has functioned perfectly during the year and has not been responsible for any interruption to service. Patrol and other work has been carried out along this transmission line throughout the year.

Manitoulin District

This district comprises the entire area of Manitoulin Island and was formed during the year in order to provide service to various sections in the vicinity of Gore Bay and Mindemoya. Various meetings were held for the purpose of explaining to prospective customers matters pertaining to procedure for obtaining service, and the utilization of electrical energy. Arrangements were finally made for the formation of a rural power district, in accordance with the various Acts and legislation governing rural distribution. Negotiations were conducted with The Little Rapids Pulp Company for a supply of power from a

development at Kagawong. It is expected that the construction work will be completed and service made available early in 1933.

THE ANNUAL REPORT

The Table of Contents, pages xxv and xxvi, conveys a good understanding of the scope of the matters dealt with in the Report, to which there is also a comprehensive Index. To those not conversant with the Commission's Reports the following notes will be useful.

In Section II, pages 5 to 52, dealing with the Operation of the Systems, are a number of interesting diagrams showing, graphically, the monthly loads on the various systems. Tables are also presented showing the amounts of power taken by the various municipalities in October during the past three years.

The rural distribution work of the Commission has proved of widespread interest and special reference to this is made in Section III, on pages 61 to 78. The power distributed to rural districts is, and possibly must always be, but a relatively small proportion of the power distributed by the Commission. The supplying of electrical service in rural areas, and especially on the farm, has, however, been of great economic benefit to Ontario. The Provincial Government grants-in-aid of the capital cost of this work have been of value to agricultural activities, and have assisted the Commission to extend rural transmission lines to many areas.

In Sections IV, V and VI will be found information respecting progress of work on new power developments and on transmission system extensions together with photographic illustrations.

About one-half of the Report is devoted to financial and other statistical data which are presented in two Sections, IX and X.

Section IX presents in summary form the financial statements relating to the operations of the Commission chiefly in the generation, transformation and transmission of electrical energy to the co-operating municipalities. It is introduced by an important explanatory statement which appears on pages 131 to 135, to which special reference should be made.

Section X presents in summary form the financial statements relating to the operations of the municipalities in the localized distribution of electrical energy to consumers. It also contains details of the costs of electrical energy to consumers in the various municipalities and tabular statements of the rates in force which have produced these costs. An explanation of the various tables and statements is given at the commencement of this Section on pages 255 to 257; and a special introduction to Statement "D," which relates to the cost of electrical service in Ontario, together with a diagram, appears on pages 380 to 383.

In its Annual Reports the Commission aims to present a comprehensive statement respecting the activities of the whole undertaking under its administration. Explanatory statements descriptive of the operations of the Commission in various branches of its work are suitably placed throughout the Report in order that the citizens of the Province may be

kept fully informed upon the working-out of the Commission's policies.

The Commission receives many letters asking for general information respecting its activities, as well as requests for specific information concerning certain phases of its operations. In most cases these enquiries can satisfactorily be answered by simply directing attention to information presented in the Annual Report of the Commission. Real benefit would result to the "Hydro" undertaking if those who are commenting upon aspects of the Commission's work would first make sure by consulting the Commission's publications that the data upon which their comments are to be based are adequate and pertinent to the subject in hand. By such a course much misrepresentation, as well as inconvenience, would be avoided.

* * * *

The Present Situation

Respecting the present power situation, the circumstances described in last year's Annual Report continued to apply throughout 1932. A still larger proportion of industrial capacity in general was idle than the proportion in 1931, and obviously the Commission must correspondingly maintain a larger proportion of reserve power capacity. To fail to do so would entail a risk of industry being prevented from resuming its former scale of activities. The power provisions made in the past in order to meet requirements of present years were on a conservative basis; that is to say, they were substantially less than would have been required under a continuance of the rate of growth that had consistently been maintained over a period of eighteen years up to 1929.

In this connection, the outcome of the Commission's financial reserve policy, followed over a period of several years, has been specially beneficial. As has been noted, extra funds placed in reserve in 1926 to 1930 with a view to cost stabilization, have in 1932 assisted in carrying the charges entailed by the necessary present provision of power reserves. It has not been necessary to increase the rates to consumers in general, and indeed, the average cost per kilowatt-hour to domestic consumers throughout the Province has continued to decrease. After all adjustments, including the special withdrawals for cost stabilization, there was a net increase in reserves of $3,741,074.72. Such a result, achieved under the difficult economic circumstances of 1932, together with the fact that the Commission's reserves now aggregate $66,145,486.61, demonstrate, it is believed, a strong financial position which is cause for satisfaction to all interested in Ontario's welfare.

With respect to the immediate outlook, it is of course impossible to predict with certainty even approximately what will be the course of general industrial activity, and of power demands which depend upon such activity. Many outstanding leaders have expressed the opinion that recovery when it occurs will be of a gradual nature. On the other hand, some features of past experience point to the possibility of very rapid resumption of utilization of power temporarily discontinued. In these circumstances, the Commission has

pursued a course of studying means whereby reserve capacity may be put to present use, while still retaining in large measure its characteristics as reserve against shortage of power for essential uses. Negotiations were in hand in 1932 for the utilization of some 80,000 horsepower on the Niagara system for steam raising in the pulp and paper industry, and the Commission is conducting similar negotiations with a view to other installations on this system and on the Thunder Bay system.

Also, the Commission has had under investigation the possibility of designing an efficient type of domestic water-heating installation that could be purchased and installed at low cost, and has been working out a plan whereby, in co-operation with the municipalities, the Commission might install such water-heating equipment without cost to the consumers. Under such a programme, the revenues from the sale of power for operation of the heaters would represent an economic saving from employment of power that would otherwise not be utilized at this time, and would in a short period, reimburse the Commission for its outlay. Besides affording to the consumers the benefit of a continuous supply of hot water at low cost under special new low rates, such a programme would give a substantial stimulus to employment throughout the Province by the expenditures upon construction and installation of equipment.

Thus by the various means that have been mentioned—maintenance of adequate power reserves for encouragement of industrial recovery; past accumulation and subsequent utilization of special financial reserves for cost stabilization; the fulfilment of all financial obligations; and the devising of means for profitable employment of capacity—the Commission has sought to afford benefit and encouragement to the activities of Ontario citizens while maintaining its undertaking in an unchallengeable physical and financial position.

Owing to the curtailment of activities in construction work, the Commission has found it necessary to reduce the number of its employees, not only in the field, but also upon its designing and drafting staffs. It is with great regret that the Commission has had to follow the unavoidable course of releasing men who have served the Hydro undertaking so faithfully. Nothing will give the Commission greater pleasure than to see such a return of general industrial and commercial activity as will afford opportunities for work for those now unemployed.

During the past year there has been noted in the press of the Province and especially in that of the smaller cities, towns and villages, an increasing tendency, in matters relating to the Hydro enterprise, to consult the authentic sources of information respecting the Commission's operations, such as the Annual Report and other official publications and statements that are issued from time to time. Moreover, while some seriously misleading statements continue to be made, tending to create quite unwarranted impressions respecting such matters, for example, as the magnitude of reserve power supplies, it is evident that such statements are being critically scrutinized and the

press of the Province in editorial articles not infrequently discriminatingly discounts adverse statements of an unfounded character. The Commission appreciates that the press has given generously to its space and services in recording and commenting upon matters relating to the Hydro undertaking, and for this the Commission especially desires to express its gratitude.

The Twenty-fifth Annual Report of the Hydro-Electric Power Commission is definitely reassuring. There have been difficult times in the past and doubtless there may be ups and downs in the future, but the record of the Hydro undertaking demonstrates that—especially under the economic stress of recent years—but very few business enterprises can parallel the past achievements and present status of the Hydro undertaking as recorded in this Report.

Respectfully submitted,

J. R. Cooke,
Chairman.

Nipigon River at Cameron Falls, Generating Station.

The Electrical Design of the Chats Falls Development

By E. T. J. Brandon, A.M.E.I.C., Chief Electrical Engineer, H.E.P.C. of Ont.

(*From paper presented at the General Professional Meeting of the Engineering Institute of Canada at Ottawa, Ont., February 8, 1933*)

THIS paper covers a general description of the electrical and building features of the Chats Falls power house and the Chats Falls transformer station. The electrical output of all generators is delivered at 13.2 kv. to the transformer station where it is stepped up to 220 kv. for delivery to the Hydro-Electric Power Commission's 220 kv. transmission system.

Diagram

Fig. 1 shows the electrical diagram for the two stations. The 13.2 kv. diagram was chosen due to its simplicity, load requirements and the fact that quick replacement of generator breakers would be afforded by the use of metal-clad breaker equipment. The 220 kv. diagram is a modified double bus arrangement for operation of the two busses as one system, requiring an average of one and one-half circuit breakers per major element (line or transformer bank). The 600-volt service power is obtained from either of two banks of three 500-kv-a., 13,200/600-volt transformers, each bank being of sufficient capacity to handle the total service load.

Power House Superstructure

The power house superstructure is 499 feet long, 70 feet wide, and 53 feet high and comprises a generator room, 50 feet in width, and three galleries located between this and the intake structure. Structural steel and reinforced concrete construction have been used throughout, except for the end walls, which are of tile and plaster so that they may be readily removed when building extensions are required for the future units.

The downstream elevation, shown in Fig. 2, has been given a simple classic treatment suitable for concrete construction consisting of fluted pilasters with entablature over, the pilaster caps and entablature being enriched with simple Greek ornament. To effect proper proportions, the facade of superstructure and substructure have been treated as a unit, that is, the pilasters extend down to the tail-race deck. Large steel window frames having deep reveals occupy the space between the pilasters. In the spandrel sections below the windows, aluminum louvres are located for the generator air inlets.

The building interior and the interior equipment have been painted in conformity with a general colour scheme, based on dark and light shades of grey-green contrasted with cream. The generator room floor has been covered with 9-inch square red quarry tile.

As shown in Figs. 3 and 4, the main operating floor is at generator room

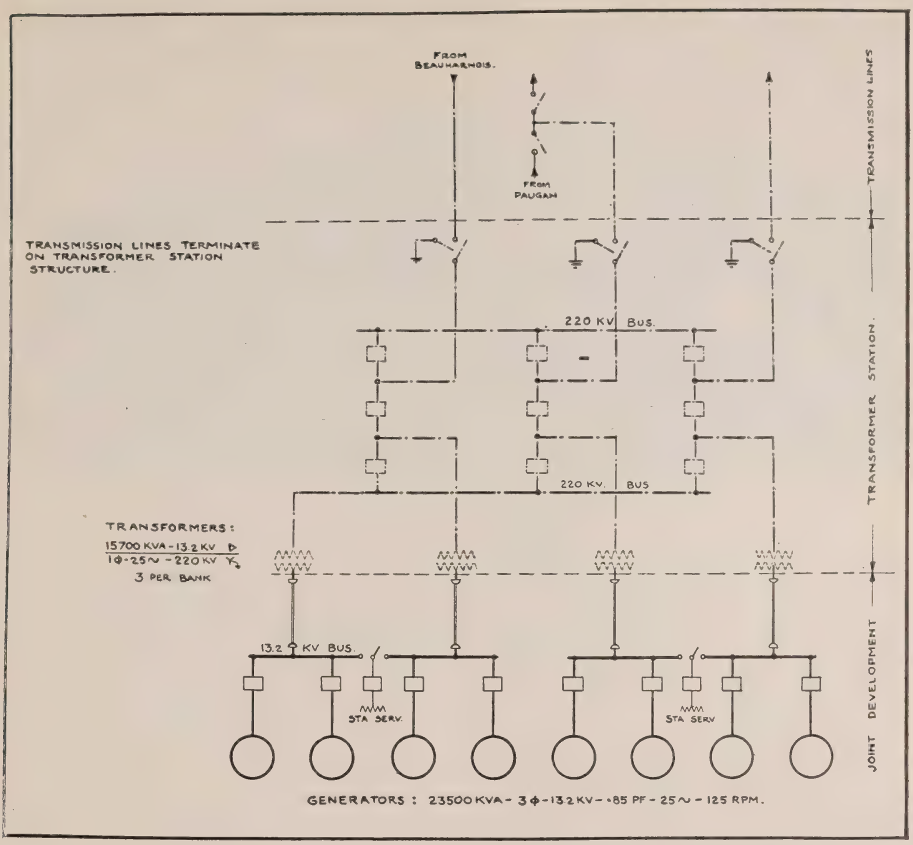


Fig. 1—Electrical Diagram for Generating and Transformer Stations.

floor level, that is, at elevation 221. The first gallery floor at elevation 223 is divided into two sections by a 13-inch concrete wall the length of the power house. The upstream section forms the cable tunnel for the main power cables to the transformers and is accessible through manholes in the floor above. The other section, open to the generator room, is occupied by the generator switchboards and rheostats, the governor pumping equipment, the station service switching and other auxiliaries. On the second gallery at elevation 236 are located the 13.2-kv. metal-clad circuit breaker structures, the service transformers and control terminal room. On the top gallery at elevation 252 are situated the control room, teletype room, battery rooms, store rooms, and offices. This top gallery extends 12 feet over the intake structure to house the head gate lifting mechanisms.

A temporary machine shop was built on a portion of the intake structure for the future No. 10 unit. In a corresponding position for the future No. 1 unit, a corridor was built to connect the power house to a building known as the pump house

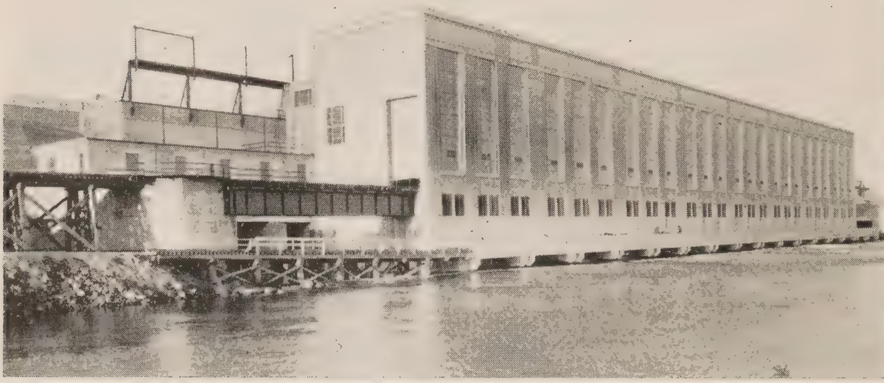


Fig. 2—Power House—Downstream Elevation.

Both the machine shop and the corridor are of tile and plaster construction so as to be readily removed when the power house is extended for the future units.

The pump house, situated adjacent to the east end of the power house, is of structural steel and reinforced concrete construction. In it are located the water pumps for supplying the power house and the transformers, an air compressor, and the transformer oil pumping and filtering equipment.

The crane equipment consists of two 90-ton, electrically-operated cranes and one equalizer beam. Each crane has a 25-ton auxiliary hook. The two cranes, with equalizer beam, are required for handling the generator rotor which weighs 175 tons. Special attachments are provided for connecting the crane hook to the turbine shaft and to the transformer core.

The floor space between units is sufficient for handling generator parts and assembly of transformers. An erection bay was, therefore, not provided. In designing the height of the superstructure, clearance was provided to permit a generator rotor with shaft to be removed from its stator and carried past an assembled unit on the downstream side. Six openings have been provided in the generator room floor for the assembly or storage of rotors. The shaft extends through an opening while the rotor is supported on temporary steel supports on the floor. A standard gauge railway track runs the full length of the power house located between the generators and the downstream wall. This track is a continuation of the spur track connecting with the Canadian National Railway at Fitzroy, Ontario. For a distance of 121 feet from the main entrance door at the east end of the station, an 11-foot gauge track is laid to accommodate the motor-operated transformer transfer truck. Between units No. 2 and No. 3, and No. 4 and No. 5, short lengths of rails have been

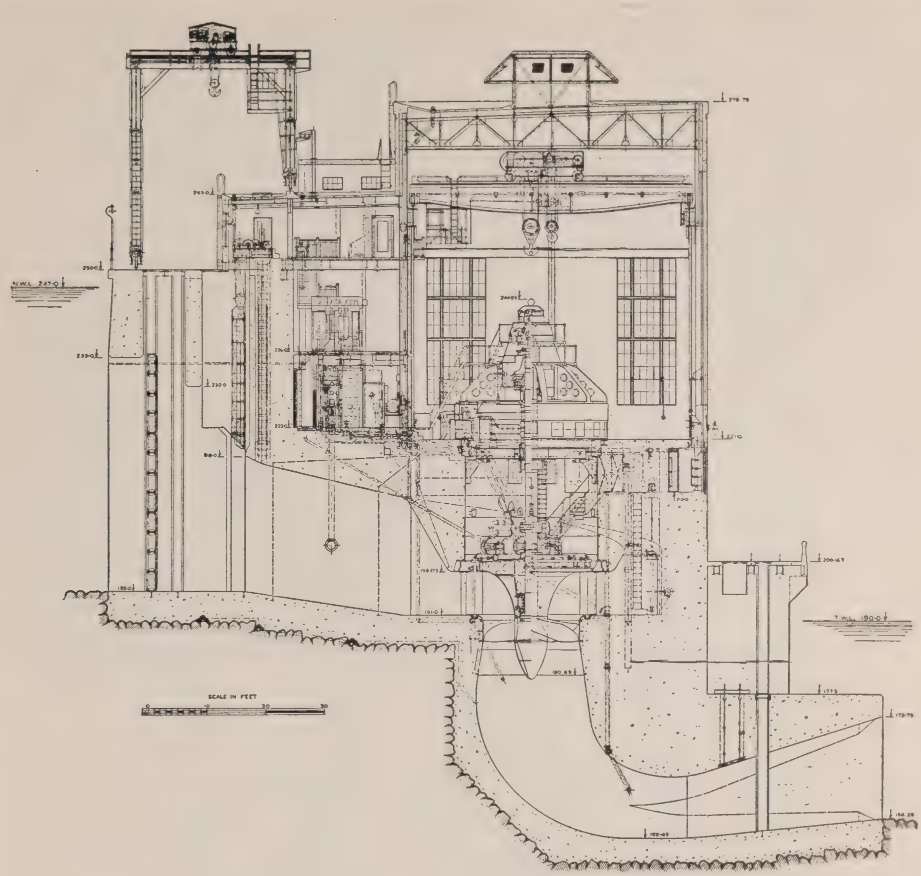


Fig. 3.—Cross Section through Power House on Centre line of Unit.

Data—Number of units installed—8. Rated capacity—53 feet head—28,000 h.p. Head—38 to 58 feet. Speed—125 r.p.m. Discharge—5,300 c.f.s. Runner—propeller type—Cast Steel. Number of blades—6. Governor—Morris Pelton No. 4. Turbine manufacturer—Dominion Engineering Works. Generator capacity—23,500 kv.-a. Generator manufacturer—Canadian Westinghouse Co.

embedded in the floor to permit of placing the transformers for assembly purposes.

To exclude external noises from the control room and teletype room the walls of these rooms are constructed of two thicknesses of 3-inch terra-cotta tile insulated from floor by one inch of cork and with the 2-inch space between tile filled with dry Insulex. The suspended ceilings in these rooms are finished in acoustic plaster, and the floors are covered with 9-inch square rubber tile. These rooms and the three offices are provided with a ventilating system which supplies water washed air treated for winter conditions as to temperature and humidity and capable of changing the

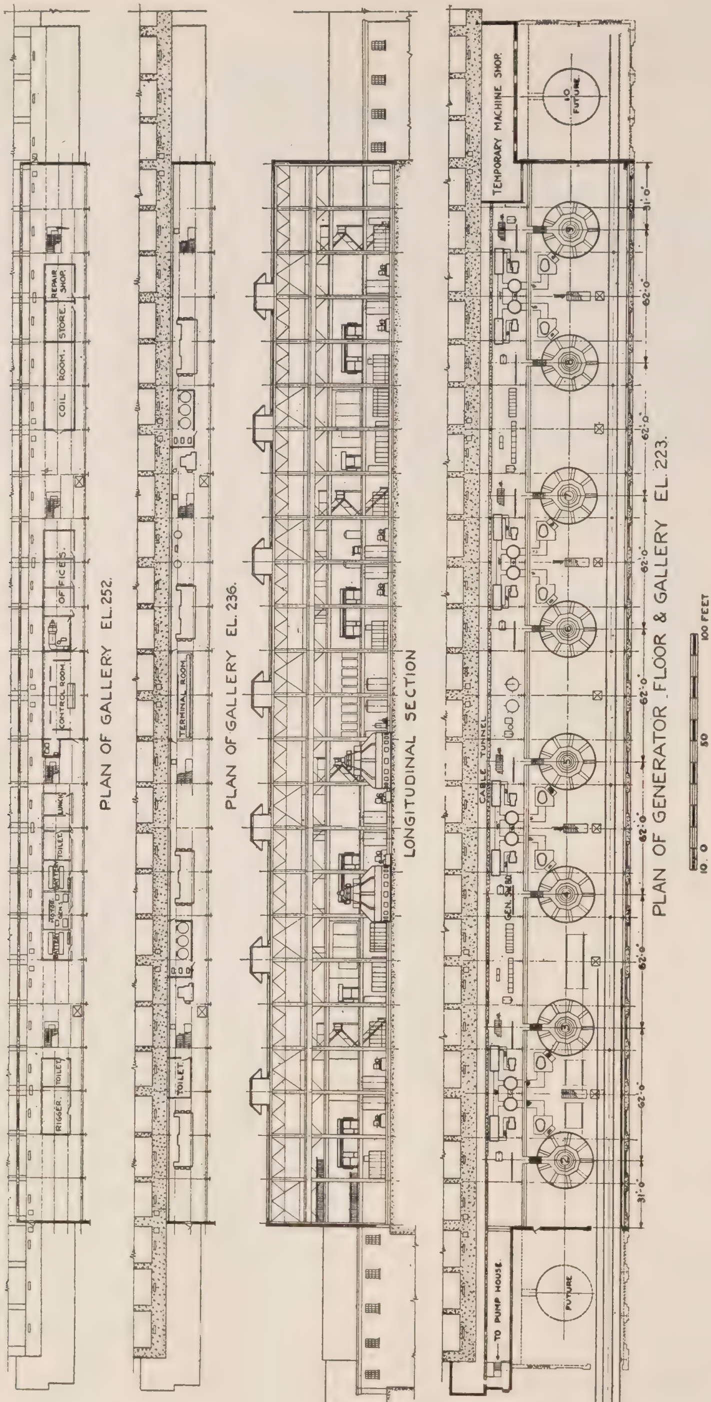


Fig. 4—Generating Station Key Plan—Electrical.

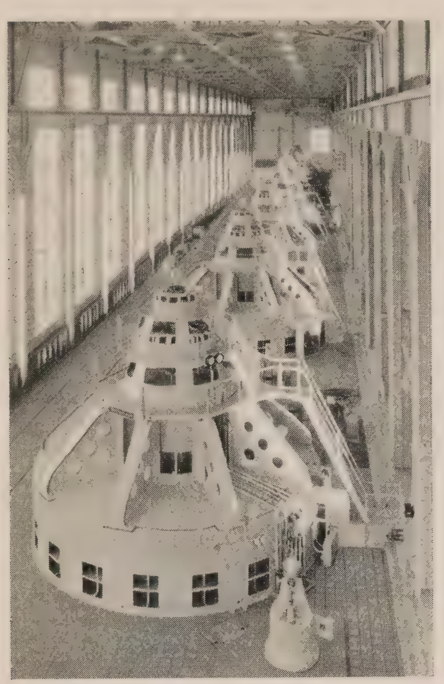


Fig. 5—Generator Room.

air once every seven and one-half minutes.

As shown in the cross-section of the power house, Fig. 3, air tunnels are provided under the generator room floor which, by means of air dampers, permit outside air, or generator room air, or a mixture of both, to be supplied to the generators for cooling purposes. Each generator requires 67,000 cubic feet of air per minute to carry away heat losses of 450 kw. This heated air provides the only source of power house heating other than for the rooms referred to above. When power house heating is not required, the heated air may be emitted through seven roof monitors having a total cross sectional area of 1,008 square feet. These monitors are equipped at their exits with manually-operated dampers on all four sides.

Generators and Excitation

All the generators (Fig. 5) are identical. Their stators are of the conventional structural design except that cast iron arms are used on the upper bracket. With the thrust bearing depressed in the upper bracket to reduce the overall height of the generator, the cast arms were found to be more advantageous than structural steel. Air is drawn in from below and discharged through the stator by means of fans on the rotor. The generator neutrals are ungrounded.

Main and pilot exciters are direct-connected to each unit. No standby source of excitation is provided due to the entirely satisfactory service experienced in other plants with direct-connected exciters. Spare pilot and main exciter armatures with shafts are provided.

The excitation system is arranged to give quick response to a major drop in generator voltage, such as would accompany line flashover. This quick response assists in maintaining synchronism between generating stations, and between generators in a station, and is especially desirable on the extensive 220-kv. system of which this station forms a part.

Main 13.2 kv. Switching

The selection of metal-clad switching equipment was made on account of space limitations, its safety features, and the short time required for its installation. There are four main-metal-clad switch structures, one for each pair of generators. These are

located on the second gallery opposite the even numbered units of their respective pairs. Each structure has a paralleling bus with two oil circuit breakers, one for each generator. The breakers are rated at 1,500 amperes and have an interrupting capacity of 30,000 r.m.s. amperes at rated voltage. Isolation is obtained by lowering a breaker by a motor-operated mechanism on a truck. Two such trucks are furnished for this purpose and for the removal of breakers for inspection or maintenance. The trucks while in the structure are operated only from the control room.

These metal-clad structures were subjected to a potential test of 60,000 volts for one minute in the factory.

MAIN 13.2 KV. POWER CABLES

Two 1,000,000-c.m., single conductor cables per phase connect generators to bus and four similar cables per phase connect bus to transformers. These are rated for 15-kv. service having 13/32-inch paper insulation and ⅛-inch lead sheath. Extensive saving in building costs, without increase in equipment costs, was obtained by using cable for these connections over that required by a rigid bus mounted on porcelain insulators. With the latter type of construction, it would have been necessary to increase the width of the power house and also increase the size of the transformer tunnel. The 13.2 kv. system is designed so that in case of insulation failure two grounds must occur before a short circuit results. The single conductor cable provided this desired condition in a very convenient way.

All cable runs are made with complete lengths of cable in order to omit the possible weakness of cable joints, the greatest run being 600 feet approximately.

Instead of constructing a delta bus at the transformers the single conductor cables connecting the bus to the transformers forms the delta.

STATION SERVICE POWER

The power supply for the operation of all auxiliaries for the development and transformer station is obtained from the two service transformer banks which are installed on the gallery at elevation 236, one in each half of the generating station. Interconnections are provided so that all service loads may be carried by either bank. The banks are enclosed in separate fireproof rooms, each with a carbon dioxide fire protection system which is fully automatic.

Water-cooled transformers were adopted mainly for the following reasons. The weight and dimensions of water-cooled transformers are less than self-cooled transformers; forced ventilating systems for the transformer rooms would have been required for self-cooled units; lower capacity transformers could be used, as increased rating of water-cooled transformers is obtained in the winter season when oil circuit breaker and other heating is required, due to the temperature of cooling water being well below 25 degrees C.

Adjacent to each transformer bank is its 13.2-kv. bank breaker, and directly below on elevation 223 are the main 600-volt feeder breakers and busses of metal-clad construction. The main feeders are in turn connected to busses in metal-enclosed

Fig. 6—Control Room.

cubicles which feed through circuit breakers to the individual loads.

The 600-volt transformer breakers and the bus tie breaker are electrically-operated from the control room; all other service breakers are hand-operated. Important auxiliaries may be fed from either service station.

In order to provide an additional safety factor on the service equipment, the transformers are insulated for 25,000-volt service and the 600-volt circuit breakers, busses and cables are insulated for 2,200-volt service.

Lighting

The illumination intensities on the floors in the generating station are approximately as follows:—

Generator Room
El. 221....... 15 foot candles
Gallery El. 223... 15 foot candles
Gallery El. 236... 9 foot candles
Gallery El. 252, (including control room).... 13 foot candles

The variation in lighting intensity on the galleries is proportional to the detail operating requirements. Certain lighting outlets in the control room and generator room and all lighting outlets at stairways and exits are fed from an automatic transfer switch such that on failure of the normal a.c. lighting supply these outlets are fed from the station storage battery. Lighting service is extended from the power house to the farthest stop-log sluices in the dam on either side, a distance of approximately 3,500 feet.

Control and Switchboards

The control of all electrically-operated equipment in the power house and transformer station is

centred in the control room located at the centre of the power house. The system adopted allows a compact arrangement of control and indication which is advantageous for operation and suitable to the limited width of the control room. A vertical indicating meter board combined with a control desk having ninety-five controllers has been installed, requiring a floor space of 140 by 40 inches (Fig. 6). The equipment on this switchboard is complete not only for the present installations but for the future additions. The length of the meter board was governed by the installation of the indicating meters for ten generators and three lines. Miniature 48-volt controllers operate interposing relays which in turn operate the equipment from a 250-volt d.c. system. The power supply for this control system is obtained from storage batteries of the sealed-top type. To afford a very reliable supply, duplicate 250-volt and 48-volt batteries are installed with a motor generator charging set for each battery as well as duplicate control busses. One 250-volt and one 48-volt battery are located in each of two rooms with the controlling switchboard and four charging sets in a centre room. Suitable switching facilitates the transfer of either battery to either of its respective chargers and to either control bus. This arrangement lends itself to systematic maintenance and upkeep of the equipment involved. The control room is 18 feet by 40 feet and contains the generator regulator boards, the totalizing meter board, and the generator ground detector and annunciator board.

Directly below the control room is the terminal room in which, as the name implies, all cables to the control room terminate. Here is located the switchboard for the generator and transformer bank standby relays.

A generator switchboard is adjacent to each generator. On each switchboard are mounted the main and exciter field breakers, the regulator contactors, the recording meters, the temperature indicator, the interposing and protective relays, and the lighting switches for each unit of power house. Near one end of each switchboard is installed the motor-operated exciter field rheostat.

In the transformer tunnel, directly below the centre transformer of each bank, is a two-panel board for the transformer relays and the temperature indicating equipment. In the centre of the 220-kv. switchyard is the relay building in which is installed a switchboard containing all line, 220-kv. bus, transformer high voltage zone and interposing relays, as well as 250-volt control switching.

(*Continued in July issue*)

Application of Electric Drive to Governor Flyballs

As used on Hydraulic Turbine Governors

By H. H. Leeming, Assistant Engineer, Electrical Engineering Department, H.E.P.C. of Ontario.

(*Continued from May issue*)

Permanent Magnet Generator for Power Supply

This, the latest system of electric governor motor drive, from test results and from twelve months of actual operating experience has every appearance of being the most successful system of governor drive yet developed.

The various mechanical governor drive systems have inherent mechanical weaknesses which led to the electric drive. The various methods of obtaining power for electric drives have each been designed as an improvement over the preceding one.

In their search for a more suitable power supply for operating governor flyball motors, the Woodward Governor Company in 1931 originated and perfected the Permanent Magnet Generator for governor head drive.

In general, it consists of a small polyphase a.c. generator which utilizes a permanently magnetized field for its source of excitation and supplies 3 phase a.c. to the governor flyball motor at a frequency proportional to the speed of the prime mover or turbine.

An illustration of such a generator which can be conveniently mounted above the main or, if provided, the pilot exciter of the main generating unit is shown.

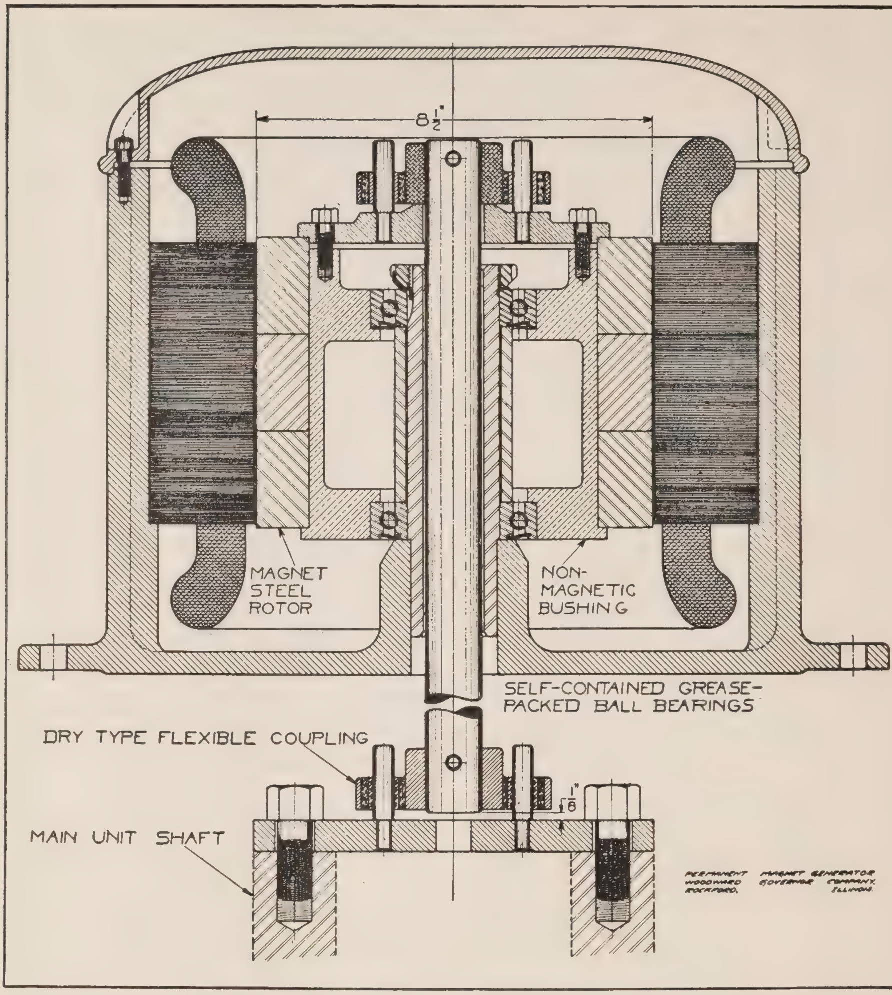
It will be noted that this special generator has a stationary armature winding and laminated armature. Permanent ring magnets of Cobalt steel form the rotating field. The rotor is driven through flexible couplings from the main unit.

Cobalt steel, although at the time of development of the permanent magnet generator, a laboratory product, was preferred for the permanent magnet rotor on account of its recognized superior magnetic qualities.

The obtaining and machining of Cobalt steel, however, for such a generator was quite a difficult matter, in fact, its use was not encouraged by the principal manufacturers of electrical apparatus when the problem was submitted to them. The fact that Cobalt steel was used for such a generator is due to the persistency and perserverance of the designers and manufacturers overcoming the difficulties encountered.

An interesting point in the development of this special generator is that it was found that better results were obtained by applying a.c. instead of d.c. to the stator winding to magnetize the rings. The peculiar thing about a ring rotor magnetized by the a.c. rotating field is the fact that the points of zero and maximum flux density are as equally spaced on the periphery as if dividers had been used to space the magnetic poles.

It has been found from tests made



Patent Applied For.

Fig. 4—Permanent magnet generator for governor control.

by the manufacturers that if d.c. is used to magnetize the rotor, same will be magnetized in spots equal to the number of teeth on the stator or each magnetic pole of the rotor will be made up of a number of magnetized strips corresponding to the stator tooth that was opposite the particular spot on the rotor at the time of magnetizing.

These magnetized spots or strips show up on the resulting generated a.c. voltage waves as a ripple or harmonic but which harmonic is not really objectionable to the proper operation of the unit.

One principal reason a.c. was used for magnetizing is that by using a sinusoidal three-phase a.c. supply the resulting flux distribution in the air gap is such that a closer approach to a sine voltage is obtained from the

unit when operating as a generator.

The number of Cobalt steel rings and the amount of stator iron used depends on the rated normal speed of the turbine. For a turbine speed of 300 rev. per min. one ring is used. For 150 to 100 rev. per min. three rings and triple stacking of stator iron is used. By selecting the correct number of poles for the governor flyball motor and the permanent magnet generator, turbine speeds from 40 to 1,800 rev. per min. can be accommodated by direct connection of the permanent magnet generator to the shaft of the main unit.

Throughout the complete range of turbine speeds, the one design of magnetic steel ring is used for the permanent magnet generator rotating field. This ring is magnetized by the respective stator to the number of poles determined by the stator winding. The required output of the magnet generator at slow speeds is obtained by increasing the stacking of the stator laminations and using two, three, or more standard permanent magnet rotor rings to give the desired air gap area.

The first application of the permanent magnet generator to commercial service was on the No. 2, 15,000 kv-a. generating unit at the H.E.P.C. Alexander Development. This new method of power supply for governor head drive was placed in service April 30, 1932, replacing the pilot exciter supply for the governor drive originally tried out on this unit.

Since the above was the first time the Permanent Magnet generator supply had been applied to any commercial service, it was considered desirable and advisable to obtain as complete information as possible regarding the performance and characteristics of so unique a generator and the drive system as a whole.

The permanent magnet generator designed and supplied for the Alexander Development is a 3-phase, 8-pole unit which is mounted on top of the pilot exciter and direct connected by means of a flexible coupling to the pilot exciter rotor.

An illustration of this installation is shown in Fig. 5.

As the rated speed of the main unit is 100 rev. per min. the 8-pole permanent magnet generator delivers 6.7 cycle power. The normal supply voltage is approximately 72.

As the power supply from the original pilot exciter drive was 6.7 cycle at 155 volts, it was not necessary to change the 2-pole, 6.7 cycle induction motor on the governor head when the permanent magnet generator was placed in service although it is likely that somewhat better results would be obtained by using a synchronous motor.

The three-phase connection from the stator of the permanent magnet generator consists of three 600 volt insulated conductors, run in conduit direct to the governor flyball motor terminals. No fuses are placed in this circuit and extra precautions were taken when installing the service to ensure reliable connections.

TESTS ON PERMANENT MAGNET GENERATOR

As a result of the tests made, some interesting information was obtained regarding the permanent magnet generator and drive system. This

Fig. 5—No. 2, 15,000 kv-a. generating unit at Alexander Development with permanent magnet generator for governor control.

information, in a simple condensed form is given in the following.

It was considered doubtful that the 110 volt governor head induction motor would start up until a considerable speed of the main unit was obtained to produce sufficient voltage, the normal voltage of the permanent magnet generator being approximately 72. Moreover, it was thought that when starting on low voltage there would be a great, or at least an appreciable "slip" or slower speed of the motor than of the generator rotor.

Careful observation of the performance of this unit indicated that the flyball motor started up when the main unit had made approximately one-half revolution, with no observable slip. The following curve (Fig. 6) plotted from information obtained later indicates the actual slip of the flyball head motor at all speeds starting from rest. It will be noted that at normal speed the slip is 1/3 of 1 per cent.

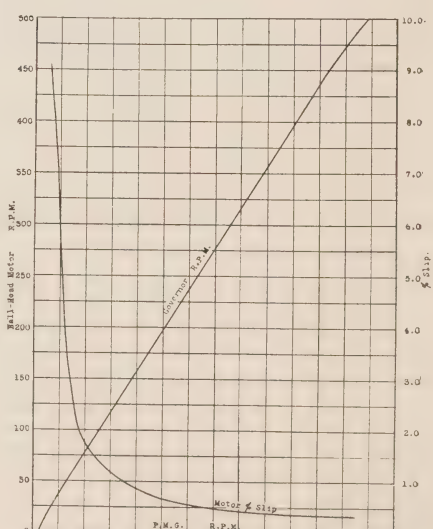


Fig. 6—Characteristics of permanent magnet drive.

Electrical surges in the main unit, such as are produced by the functioning of the generator voltage regulator or when synchronizing, which rendered the pilot exciter power supply entirely unsuitable for this installation, had no effect on the permanent magnet drive system as observed and confirmed by oscillograph records.

Artificial mechanical surges, caused by surging the pilot valve of the governor, were quickly damped out and the speed restored to normal.

Oscillograph records were taken of the voltage generated by the permanent magnet generator and of the current taken by the motor driving the flyball head under the following conditions:—

(1) On starting up the main unit from rest.

(2) With main unit at normal speed, no load and separated from the system.

(3) During synchronizing the unit with the system.

(4) At normal speed, unit carrying 10,000 kw.

(5) At 52 rev. per min., also at 112 rev. per min.

(6) With unit off system and operating at normal speed, the pilot valve of governor was surged down and up manually.

(7) During rejection of about 4,500 kw. load.

Under each of the above conditions there was no disturbance apparent in the governor flyball drive system.

The generated voltage of the permanent magnet generator shows a straight line characteristic of generated voltage as compared to speed, which can be understood, as the flux density in the permanent magnet generator air gap is constant at all speeds; the generator voltage increases directly with speed. The matter of permanency of the magnetization of the field of the special generator remains to be determined by time and service.

Although re-magnetizing the permanent magnet generator has not yet been found necessary or attempted in the field, same is considered to be a comparatively simple matter. The generator, according to advice from the manufacturers, can be remagnetized by either a.c. or d.c. whenever necessary, who, however, advise that no better means of magnetizing has been found than that of applying 1,100 to 2,300 volt, 60 cycle, 3-phase power for two to three seconds to the stator connections of the permanent magnet generator with the rotor in place and free to turn. There would be no harm done to the generator itself by a short circuit developing at the stator terminals. The short would, however, have the effect of demagnetizing the permanent magnets. Re-magnetizing would, however, based on factory experiments, restore the machine to its original condition.

From test data it would appear that the original saturation of the permanent magnet generator may be permanent for the life of the unit, providing the flyball motor is not stalled or the permanent magnet generator leads short circuited.

Since the governors at the Alexander Development embody a very conveniently operated gate limit device which can readily be used for

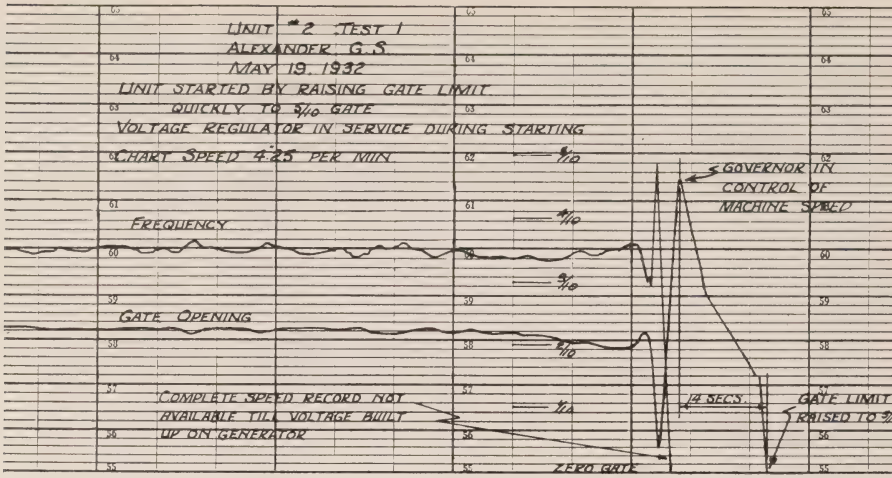


Fig. 7—Test record of starting generator.

closing the gates completely, this is generally used to shut the unit down, thus leaving the adjustment of the speeder spring of the governor at normal setting of 60 cycles or normal speed no-load. It was, therefore, felt that if the governor motor drive system, using a permanent magnet generator for the power supply was positive so that the governor would be brought into action quickly, it would be feasible to bring the unit up to no-load speed by merely removing the gate limit. Records at 4.25 inches per minute were made of two trials of this method and from same it was noted that the control of the gates by the governor was identical in each case.

From Fig. 7 it will be noted that 14 seconds after the gate limit was removed the gates are starting to close from the maximum opening attained and in about another seven seconds the gate has completed its cycle of surges and is at normal opening for rated speed no-load. The speed or frequency record is not complete since this element required voltage from the main unit which requires some time to build up, probably about 14 seconds.

This property provides a very convenient method of handling the unit and lends itself to more convenient remote operation of generating units.

Storm of June 7

On Wednesday, June 7th, an unusual thunder storm accompanied by high winds of cyclonical proportions, crossed parts of western Ontario causing very considerable destruction in certain sections. This storm appeared to have released its greatest violence in the vicinity of St. Marys, Woodstock, Waterdown, which is near Hamilton, and certain parts of the Niagara peninsula.

The Commission, approximately 25 years ago, constructed its main transmission line from Niagara Falls to Toronto, and not once in that time

have winds been experienced of sufficient velocity to carry away the steel towers until this date when a number of towers in the vicinity of Waterdown were completely demolished. In the same vicinity, the storm also toppled over approximately 75 trees, many of which were at least 100 years old, indicating that winds of this velocity had probably not been experienced in the last century. A similar experience occurred in the township of Saltfleet and to a minor degree in various parts of the Niagara peninsula.

One interesting phenomenon occurred at the Queenston power house, which is situated many feet below the gorge proper. The wind, in crossing the gorge at this point, created a very high vacuum which was evidenced by the fact that a large area of metallic roofing attached to various parts of the power house was lifted off, and a number of windows were blown outward.

A number of local distribution systems suffered severely due to trees being uprooted and carrying the lines to the ground. The municipality most affected appears to be St. Marys which lost 10 to 15 per cent. of the trees in the town, which temporarily demoralized the electric service.

It is an interesting fact, however, that in spite of these almost unprecedented difficulties, the Commission was able to maintain service to practically all the municipalities in the affected area, with the exception of short interruptions caused by troubles in the main high tension lines. This, however, could not have been accomplished if the Commission did not obtain its power from a large number of points. At one time the entire Toronto area was carried by the power plants on the Ottawa River and in the province of Quebec. Had power not been available from the east, the disruption of the main lines between Toronto and Hamilton would have been a very serious matter for the city of Toronto. It is interesting to note that even under these great difficulties, the municipalities were able to resume service in a comparatively short time.

R. H. Myers, Stratford, Retires

Mr. R. H. Myers, for twenty-three years Secretary-Treasurer of the Public Utility Commission and for thirty-seven years a Municipal Official, retired from active service on June 1st, 1933. "Chief" Myers, as he was more familiarly known, was one of the first employees of the Stratford Commission and was active in the organization of the first thirteen municipalities to enjoy Hydro. He was an ardent supporter of Hydro and a regular attendant at the conventions of the O. M. E. A. and A. M. E. U.

Behind the Scenes at the Zoo Aquarium

The first of the two Dr. Mann Juvenile Lectures was delivered on the afternoon of Wednesday, January 4th, by Mr. E. G. Boulenger, Director of the Aquarium, Zoological Society of London, his subject being "Behind the Scenes at the Zoo Aquarium".

The lecturer, who was briefly introduced by Colonel Sir Henry McMahon, G.C.M.G., G.C.V.O., explained that the sea water in the Zoo aquarium comes from the Bay of Biscay. It is conveyed to the London docks in the ballast tanks of large liners and is then transferred to barges on the Thames, from whence it is taken by lorry to the Zoo. Fish placed in artificial sea water cannot survive. They fall ill, go blind and eventually die. If however, only 2 per cent. of natural sea water is added, the fish thrive. This is due to a mysterious chemical in the water, the nature of which no chemist can explain.

The Aquarium contains over 200,000 gallons of sea water. This is placed in underground reservoirs and kept in constant circulation. It is pumped into a high level reservoir on the top of the Mappin Terraces, from whence it runs down to the Aquarium tanks. It then passes through sand filters before returning to the main reservoirs.

A number of the exhibits are brought to the Zoo by air, and some are transported in a dry state. Lobsters, for example, are just packed in seaweed. If, after being unpacked after a long journey, they were to be placed immediately into their natural habitation, they would drown, their gills having become full of air during transport. To obviate this, they are placed on arrival on their backs in water which only just covers their gills. In time the air is replaced by the water and they recover. Herrings are extremely difficult to exhibit, as it is necessary to capture them under water. As soon as they are brought to the surface their scales fall off and they die. The octopus is another difficult creature to capture, because it is apt to commit suicide on the journey by ejecting an inky fluid from a special gland.

Certain specimens, such as the East Indian coral fish (which lives inside an anemone) and lobsters from Madeira, arrive at the Zoo as the result of certain marvellous diving feats of the natives.

The lecturer stated that an electric eel, always a popular exhibit in the Aquarium, can give a shock equivalent to 400 volts, when "shocking" its prey. The small electric catfish of East Africa makes use of its electric powers to earn a living, but whereas the eel kills its prey by shocking it, the catfish merely touches a large fish with its tail, causing it to bring up its last meal, which is promptly devoured by the catfish.

A large number of the inmates of the Aquarium are fed on horses' heart, a delicacy to which all fish are partial, even confirmed vegetarians. Shrimps, prawns and sandhoppers form the diet of many small fish, and so great is the demand for these "sea-fleas" that a man is specially employed by the Zoological Society to collect them. The way to a fish's heart, the lecturer explained, is, as in most living beings, through its stomach, and most captive fish become very tame, especially at mealtime. Even large conger eels allow themselves to be handled; but should a keeper be seen with a net, every specimen in the tank immediately takes cover and disappears.

The characteristics of some fish are peculiar. The puffer-fish from

Madeira, for instance, will fill its mouth with water and deliberately spit at visitors taken "behind the scenes". This, however, is not done with any malicious intent, but is merely analogous to the monkey's greeting of an outstretched paw. At the Zoo, all the fish are deaf, and any liveliness which is displayed at the approach of a keeper is not due to any sense of hearing, but to the food pail, which is visible to them. An account was given of an aquatic newt, the Mexican axolotl, that metamorphoses into a land salamander on being given a single meal of thyroid gland. The gills and fins are lost, eyelids appear, and within a month of being given its pill it leaves the water and takes up a terrestrial existence.

Little is known of the nocturnal habits of fish. Many sleep, some on their sides against the rockwork of their aquarium, others on the bottom of the tank. Hungry trout will sometimes go in search of food at night, which accounts for the fact that anglers have been known to catch them after dark.

The lecturer showed a number of interesting slides, dealing with the Fighting fish of Siam, on which large sums of money are wagered at tournaments in that country; the Mexican swordfish, which produces living young and changes sex; angler fish in which the males are 1,000 times smaller than the females; fish which contain poison in their spines and eject it in the same manner as do snakes; perch which climb trees in search of water when the ponds they live in dry up, and many other varieties.

It was stated that some of the exhibits in the Zoo Aquarium are over fifty years old.

The lecturer concluded his talk with an anecdote of an old lady who arrived at the gates of the Zoo one evening with a large basket, and asked the attendant for some fish. She was under the impression that the specimens in the Aquarium were sold to the public every Saturday night.

A film, showing the habits and characteristics of sea life, terminated the lecture, and on the motion of the Chairman a hearty vote of thanks was accorded to Mr. Boulenger for a most interesting and entertaining afternoon.—*Journal of the Royal Society of Arts.*

THE BULLETIN

Published by
HYDRO-ELECTRIC POWER COMMISSION
of Ontario

620 University Ave.
Toronto

Subscription Price $2.00
Per Year

The Principles of the Operation and Administration of the Hydro-Electric Power Commission's Systems

By F. A. Gaby, D.Sc., Chief Engineer, H.E.P.C. of Ont.

(*Address to the Rotary Club of Oshawa, April 10, 1933*).

As business men, you are interested in the cost of power as an important factor in your commercial operations. It further interests you in the benefits that have accrued to the employees and their families in the comforts and satisfaction of mind that they experience in the raised living conditions brought about by the availability of cheap power.

The Hydro-Electric Power Commission's proposition has brought many benefits and advantages to the people of Ontario. There is no other organization of its character, or magnitude, in the world which has as low rates or as great a consumption per capita as the Hydro undertaking, except possibly Norway where larger quantities of power are used for basic industry in the production of raw products. It would not be amiss to outline briefly, and bereft of its technicalities, the underlying principles of the operation and administration of the Hydro-Electric Power Commission's systems.

At the outset it should be emphasized that the legislation and contracts governing the Hydro-Electric Power Commission's undertaking definitely establish its status as being essentially not a department of the Government, but, rather, a self-supporting co-operative business enterprise, owned by the co-operating municipalities of its several systems. The Commission, although appointed by the Government, acts as trustee for the municipalities, one member of which must be a member of the Government, which is reasonable in view of the Government's responsibility in regard to financing.

The Commission is given administrative jurisdiction over all phases of its operation on behalf of the co-operating municipalities. The Power Commission Act explicitly assigns to

CONTENTS

Vol. XX No. 7
July, 1933

the Commission direct and sole jurisdiction over such vital phases of the undertaking as applicable to the purposes of the same, such as:—all income received by the Commission; the construction of the necessary works for the generation or purchase of the requisite supply of power and the transmission of the same to the municipalities; the apportioning of the costs amongst the municipalities for which it acts as trustee; and the control of the debenture issues and rates of the local systems. In general, the Commission's status is such as to ensure efficient operation along business lines with complete absence in the past of political domination in conducting such operations. In order, however, to secure the lowest possible cost of financing, the funds acquired for capital expenditure of the Hydro-Electric Power Commission are loaned, or guaranteed, by the Province. Consequently it is encumbent upon the Provincial Government to see that investments and major commitments of the Commission are such as will ensure the integrity of the capital, as well as the regular payment of interest upon the loans made.

Essentially the Province acts in the capacity of a banker and not in that of owner or administrator. Except for enacting legislation, appropriating funds for capital and requiring an annual report from the Commission, the Legislature, or the Government of Ontario, itself exercises no administrative jurisdiction with regard to the undertaking, and the Government confines its activities to matters connected with the security of the loans and guarantees and the performing of certain requirements called for by the legislation.

In a limited number of matters, in all of which the interests of the Province, as creditor of the undertaking, are concerned—such as acquisition of property for certain purposes, borrowing of funds, and important contracts for purchase and sale of power, the Commission's executives must secure the approval of the Lieutenant-Governor-in-Council. Even with regard to these matters, however, it is important to remember that the main responsibility rests with the Commission, which decides the properties to be acquired and negotiates the contracts in the interests of the municipalities.

It is to be recognized also that from time to time, where special circumstances have called for special Government assistance or participation, special procedure in regard to specific properties has been adopted. For example, in 1916 the Central Ontario System was purchased by the Province, and the Commission, in addition to its main activities as trustee of the municipalities of other systems,

had for some years, until the Central Ontario municipalities were ready to take over the properties, which occurred in the year 1928, the status of trustee for the Province in respect of these properties. Somewhat similarly in the case of activities in Northern Ontario, where circumstances have called for special governmental assistance, a modified form of prodecure has been adopted. Such additional functions performed by the Commission, however, do not interfere with the Commission's carrying out of its obligations as trustee for the participating municipalities served by other systems.

As is well known, one of the fundamental principles governing the operation of the co-operative municipal Hydro undertaking is the supplying of electrical power at cost.

The Commission, as trustee for the municipalities, is required, upon their entering into contractual obligations to supply power, to provide the necessary generating, transmission and other works necessary to deliver power at the limits of the municipalities.

The local distribution system within the municipality is financed by the municipality and administered and operated by a local Commission appointed usually by the electors of such municipality. The relation of the Hydro-Electric Power Commission, after such has been accomplished, is that of a public service Commission, in which it is empowered to approve of debenture issues for such purpose, and control rates to the consumers within the systems in addition to its functions as a public utility, of delivering power at cost to the municipalities. By "cost" is meant a distribution of all charges annually for interest on investment, sinking fund for amortization of such investment, depreciation and renewal for the maintenance of such properties, contingencies, maintenance and operation, the basis of which is the equitable use that the municipalities make of the investment of the Commission, calculated upon the average of the monthly peaks.

Interest is charged at the average rate of the cost of money in any one year to the Government, upon advances made to the Commission, plus such interest at the actual rate upon the Commission's debenture issue, which are usually guaranteed by the Province.

The sinking fund is calculated so as to accumulate sufficient funds to return to the Government the moneys loaned over a period of 40 years. The rate is established at 1.053 per cent. per annum, compounded at 4 per cent. improvement. The excess earnings that the Commission obtains over and above the 4 per cent. are credited to interest account, thus reducing the cost of power.

The renewals usually are calculated at ¾ per cent. to 1½ per cent., based upon a sinking fund basis, which calculation is upon the weighted average of the various items of the capital entering into the work, and ½ of 1 per cent., for insurance and obsolescence, called "contingencies", plus direct operation and maintenance distributed as above.

The total of such charges usually works out at about 10 per cent. on the actual investment on the average.

Of the total of the above costs 80

per cent. to 90 per cent. is fixed by the original commitments; therefore you will appreciate that on the basis of cost to the municipalities it is impossible to vary the rates, or costs to the municipalities, as in other commodities. In each year the charge to the municipalities is adjusted to cost; therefore the rates cannot fluctuate widely.

To meet conditions of to-day in the commercial and industrial fields, the Commission during prosperous years, in addition to the charges above mentioned, accumulated sufficient extra funds which are set aside for the stabilization of rates and in the Niagara System from $9,000,000 to $12,000,000 has been accumulated for this purpose.

The financial responsibility for defraying the cost of service rests primarily upon the consumers themselves,—that is to say, upon those who actually benefit from the electrical service. It is these and these only who in their rates for electrical service pay all expenses incurred year by year, and also repay the capital costs of the undertaking. Each municipality guarantees its own share of the undertaking and thus assumes a secondary responsibility. No Hydro municipality, however, has ever had to levy taxation because of failure of electrical consumers to meet costs. Most of the local Hydro utilities have built up substantial reserves and surplus which protect the undertaking, and the Commission also in connection with the collective portion of the undertaking which it administers, has likewise built up substantial reserves, notwithstanding the fact that 86 per cent. of the domestic consumers have rates at less than 2 cents per kilowatt-hour and one-tenth of 1 per cent. of 6 cents and over, which is in strong contrast to the average rate in the United States of 6 cents per kilowatt-hour.

Thus the Hydro-Electric undertaking administered by the Commission is a self-supporting business enterprise functioning under independent Commission control and administration, which throughout more than two decades has shown its ability not only to provide electrical service for its consumers at exceptionally low costs, but also to conduct its financial operations on an unquestionably sound basis, meeting promptly all obligations including those to the Province, and laying aside adequate reserves. The remarkable growth of the Commission's undertaking is shown by its investments and reserves.

In 1912, which represents the actual commencement of the commercial operations of the Hydro-Electric Power Commission undertaking, the Commission was serving 33 municipalities, had constructed 624 miles of transmission lines and had available 100,000 horsepower, although the peak at that time was only 21,155 horsepower.

It might be pointed out at this juncture that the original Hydro-Electric Power Commission undertaking was established on the basis of purchased power from, at that time, a foreign corporation with its head office in the United States. The number of consumers served by the municipalities was 38,713 and the investment of the Commission

$4,109,000 and that of the municipalities slightly over $6,000,000, or approximately $10,000,000 total investment in the Hydro-Electric Power Commission undertaking.

In 1932 the number of municipalities had increased to 747—27 cities, 95 towns, 125 villages, 142 Police Villages and 358 Townships; transmission lines, high and low tension, to approximately 15,000 miles; the total available capacity, including purchased power, to 1,623,152 horsepower as of October 1st and 1,760,000 after this date; the winter peak, distributed, 1,131,000 horsepower, and the contractual obligations approximately 1,300,000. The consumers had increased to 612,000, with capital investment of $273,228,754.27, including about $6,500,000 for railways, and the reserves of the Commission, although they had reached $13,000,000 in 1924, had increased to $66,000,000 at the end of 1932, with a total investment of the municipalities and the Commission of over $370,000,000, with reserves and surplus in excess of $123,000,000. Now I have referred to very large sums and it may appear to some that these are in excess of the requirements for the reasonable protection of the properties. This is no doubt adequately safe but not unreasonable when one considers the $370,000,000 of capital investment.

For the year 1932, in order that rates be maintained at or near normal, the Commission appropriated from contingency funds an amount of about $3,000,000, and notwithstanding this withdrawal the general reserves of the Commission increased by $3,700,000 during the year to a total to date of $66,000,000, made up as follows:—

Sinking Fund Reserves..........	$24,639,128.46
Renewals Reserves	22,604,698.70
Obsolescence, Contingencies and Stabilization Reserves..........	14,938,399.89
Public Liability and Staff Insurance Reserves.......	3,854,019.25
Guelph Radial Railways.......	109,240.31

There have been difficult times in the past and doubtless there may be ups and downs in the future, but the accumulated reserves show that Ontario's municipal undertaking rests upon a sound foundation and has substantial reserves of power and ample financial reserves.

The equity of the municipalities, which has been referred to on a number of occasions in the systems they are situated in, is represented by the total of sinking funds which have been paid or credited to them in their accounts, and amounted to over $22,000,000 at the end of 1932.

In the last three years, 1930, 1931 and 1932, inclusive, there are few organizations that can show an achievement as great as that of the Hydro-Electric Power Commission in that it has accumulated in excess of $16,000,000 during such period.

As I have stated previously, the Commission acts in the capacity of trustee to the municipalities in the administration and operation of these large undertakings, all of which belong to the municipalities as the

rightful owners. The local commissions are to be congratulated and commended for the excellent work which they have done in carrying out the operations of such local commissions in a business-like way.

Now I will refer to that system in which the municipality of Oshawa is specifically interested, — what is known as the Eastern Ontario System, comprising the amalgamated systems of Rideau, St. Lawrence, Ottawa, Central Ontario and the Madawaska, which territory extends on the west to Whitby, and to the Quebec boundary on the east.

In 1916 the Central Ontario System, or the larger of the above systems, was, upon the request of certain municipalities, acquired by the Government, who proposed to operate the same until the financial position of the properties had reached a stage where it would be satisfactory for the municipalities to take ownership by the elimination of extraneous properties, such as electric railways, gas plants, pulp limits, etc. In order to do this it was necessary for the Commission, as trustee for the Government, to reorganize the financial structure and place the distribution systems of the 22 municipalities involved, upon the same basis as to rates and accounting as other Hydro municipalities.

Although the revenues were insufficient to pay expenses in full at the beginning, by 1928 this work of rehabilitation had been accomplished, with remarkable results in that rates had been reduced by over $5,000,000, in addition to setting up reserves for renewals and contingencies amounting to $2,500,000 (not including Nipissing) leaving the properties in a sound financial position.

In the early part of 1927 the Commission advised the municipalities within that district that the Government was prepared to hand over the properties. The municipalities appointed a committee of business men to investigate the matter, which resulted in the formation of an association known as the Central Power Association, of which your esteemed citizens Mr. Mason was President and Mr. Conant a Member of the Executive.

After a thorough investigation the Association reported to the municipalities that they take over the same.

The capital within the Eastern Ontario Power System including Nipissing to-day is approximately $20,000,000, the reserves have increased from $3,370,000 to $5,228,000 in a period of four years and the municipalities have an equity in the works established by the Commission of over $750,000 — accumulated since 1928.

The results have been remarkable from an operating standpoint. For the year 1932 there was a net surplus of $73,000, of which $25,302 was returned to the municipalities after $48,000 of exchange on account of interest had been placed to the credit of contingencies reserve, in addition to which Reserves was charged with obsolescence, renewals and contingencies of $549,000.

The total capacity available for use in the Eastern Ontario System is between 110,000 horsepower and 120,000 horsepower, dependent upon water flow, with optional amounts

up to 70,000 horsepower additional from the Gatineau Power Company and water power sites capable of developing up to 150,000 horsepower on the Madawaska System. The maximum load in the last few years has reached 93,000 horsepower.

55 municipalities are involved, with 36 rural power districts. The urban municipalities and the municipal systems on the Eastern Ontario System have a capital investment of approximately $7,110,785; debenture debt, $3,096,709; depreciation reserves, $1,453,247; surplus, $2,150,372, and an equity in Hydro undertaking, $750,000.

The percentage of debenture debt to total assets of the local municipalities amounts to the extraordinary amount of 29 per cent. The operations of the local distribution systems for the year 1932 show a surplus of approximately $160,000 after setting aside reserves for debenture debt payments, renewals and sinking fund, of $330,000.

Oshawa, along with the other municipalities, undertook in the year 1928 to acquire and operate its own distribution system, and its success is somewhat the same as others under similar circumstances.

The purchase price of the system was $310,000 in 1928; approximately $50,000 has been paid off. The plant value is $407,000; debenture balance $260,000.

During the past four years of operation there has been accumulated $135,000 in surplus, which has been reduced by $46,000 rebates to the consumers and a small loss during the last operating year, leaving a balance of $88,000 surplus, in addition to the setting up of $44,000 in reserves and a payment of $50,000 of debenture debt, with a reduction in rates in 1930 of $29,000 and 1931 of $38,000 per annum.

The reserves, or equity in the Hydro System also amounts to $151,500, a fine accomplishment during the last few years of depression and the net cost to consumers has been the lowest in history,—an average in 1932 of 2.5 cents domestic and 2.7 cents commercial, and $20.34 for power.

This is a truly wonderful statement when one realizes the position in which most of our industries find themselves after three years of depression.

The Electrical Design of the Chats Falls Development

By E. T. J. Brandon, A.M.E.I.C., Chief Electrical Engineer, H.E.P.C. of Ont.

(*From paper presented at the General Professional Meeting of the Engineering Institute of Canada at Ottawa, Ont., February 8, 1933*)

(*Continued from June Issue*).

Transformer Station

The main power transformers are located on the roof of a concrete tunnel which is divided longitudinally into two sections. The section next to the dam forms the cable tunnel for the 13.2-kv. main power cables to the transformers, and the other portion forms the operating tunnel which connects through the pump house with the generating station. This latter tunnel contains the water and oil piping, switchboards, and cable pans carrying the control cables from the power house to the transformers and to the 220-kv. switchyard.

Four banks of transformers and one spare transformer have been installed, each bank consisting of three 15,700-kv.-a., single-phase, 25-cycle, 127-220Y/13,200-volt, oil-insulated, water-cooled, non-resonating type transformers as shown in Fig. 8. The transformer high voltage windings are connected in star with the neutral points solidly grounded.

For a distance of 85 feet from the power house, a transformer transfer track parallels the railway track on a common centre line and connects to a manually-operated turntable of 164 tons capacity, capable of turning 360 degrees (Fig. 9). At an angle of 52 degrees to these tracks is a continuation of the transformer transfer track which parallels the transformer tunnel. A motor-operated transfer truck conveys the completely assembled transformer from the power house to its pocket, an average distance of 355 feet. Seventy minutes are required for three men to perform this transfer which includes placing the transformer on the truck, turning the turntable and pulling the transformer into the pocket. This last operation is done by the truck and requires about twenty minutes of the total time.

Water-cooled transformers are used because their cost is lower and an adequate supply of cooling water is available from the river.

The 220-kv. structures are of typical galvanized structural steel design and may be divided into three sections: the transformer structure at which the transformers are located; the intermediate structure; and the switchyard structure at which the 220-kv. busses and switching equipment are located.

The electrical layout is on a basis of 12 feet minimum clearance between phases and 7 feet 6 inches minimum to ground. Both these figures are based on 30-inch diameter grading rings being provided; as these rings have not been installed, actual clearances are somewhat higher.

The oil circuit breakers have a

current rating of 800 amperes and an interrupting capacity of 6,300 r.m.s. amperes at rated voltage, the arc rupturing time being 0.15 seconds. They are equipped with condenser bushings suitable for operation at 127 kv. to ground, i.e. 220 kv. solidly grounded or 187 kv. isolated neutral system. These breakers are such that bushings for a 220-kv. isolated neutral system may readily replace the lower rated bushings. A potential tap is brought out from each bushing to which is attached a potential device on each line breaker for relay purposes.

Although low cold test oil is used, nine 600-watt immersion heaters are installed in the oil of each breaker tank to ensure maintenance in extreme low temperatures of the speed of opening. A specially designed steel structure with chain block which may readily be assembled on top of the breakers has been provided for replacement of bushings.

The insulation of the disconnecting switches and the bus supported on post insulators consists of six 14½-inch high units. For the strain busses, twenty 10-inch diameter, 5-inch standard suspension units are used and for busses in suspension, eighteen similar units. For all strain busses on which tap connections were not required 795,000 cir. mil. steel reinforced aluminum cable is used, the balance of the strain busses and taps being hollow conductor copper cable having conductivity of 750,000 cir. mil. copper cable and having an outside diameter of 1.249 inches.

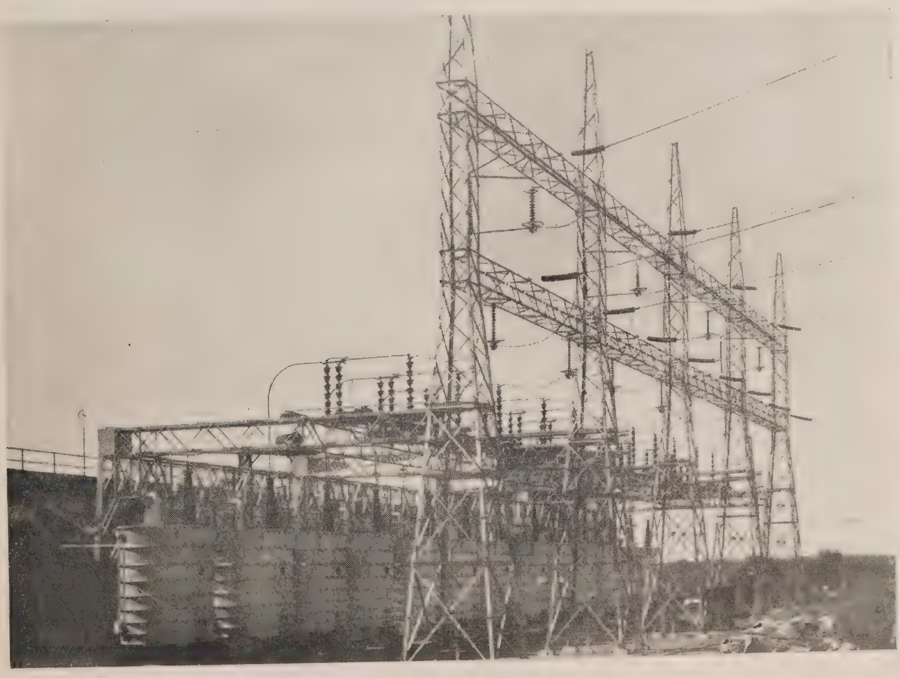


Fig 7—15,700 kv.-a. Transformers.

The rigidly supported bus is 2-inch I.P.S. copper tubing. All bus connections are clamped except the connections of aluminum cable to copper terminals which are compression type.

Ground System

The design of a ground system for the development and transformer station was a difficult problem because the sites are practically solid rock with few basins of soil. To obtain a low ground resistance under such conditions made necessary the installation of seven 5-foot by 5-foot copper plates in the best and most widely separated soil pockets. These plates are connected through ground test links to a 500,000, c.m. ring ground bus which encircles the transformer station and extends through the power house. The frames of all electrical equipment and the steel structures are connected to this ring ground bus.

In the transformer station No. 4/0 copper lateral busses are installed underground immediately under and, therefore, parallel with the sky wires. These busses are connected to the sky wires at each tower and also to the main ring bus.

The transmission line sky wires are connected to the station ground system through ground test links so that the station ground system may be isolated for test purposes from the transmission line ground system.

Accurate measurements were made to determine the station ground resistance. The results of these measurements gave a resistance of 1.05 ohms, a most gratifying value for the rock conditions encountered. With this value of resistance, it is calculated that the maximum voltage gradient that can be obtained between the station ground system and a remote point will not exceed 1,800 volts.

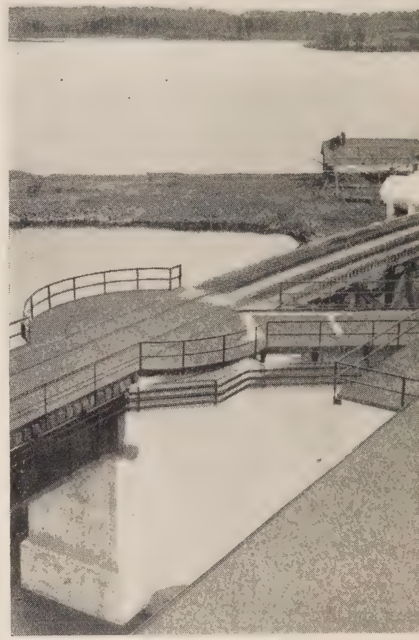


Fig. 8—Turntable for Transformers.

Lightning Protection

Extensive study was given to the lightning protection of the equipment in the transformer station. Protection has been provided by co-ordinating the insulation of the transmission lines on the sections adjacent to the station with the station insulation and by safety gaps at vital points. An extensive system of overhead ground wires has been installed over the station busses and equipment. The transformers are the non-resonating type.

Special transmission line towers,

Fig. 9—General View of 220-kv. Switch Yard.

Fig. 9, have been installed on the lines for a distance of approximately one-half mile from the station. These towers permit two overhead ground wires per circuit, giving a minimum radial clearance between each phase wire and the nearest ground wire of 31 feet which occurs at the towers. The spacing between ground wires and power conductors close to the station was increased over that used on the balance of the lines to make it more difficult for a lightning surge to jump from the ground conductor to the power conductor. These overhead ground wires are carried throughout the station with consistent spacing between them and power conductors. All the main towers of the switchyard, intermediate, and transformer structures are extended 22 feet above the top girders to carry these ground wires. Cross bonding is provided across each row of such towers in order to assist in dissipating lightning surges. These wires are grounded to the station ground system by No. 4/0 copper cable extending down each tower. It is calculated that more than 17,000,000 volts would be required on one of these ground wires before there would be danger of a flashover occurring from ground wire to power conductor.

The overhead ground wires terminate at the transformer structure. Additional protection for the transformers is contemplated by means of two lightning masts approximately 150 feet high, one at each end of the group of transformer banks. The tops of these two masts would be connected by an overhead ground wire. Provision has been made so that an arrester may be installed at each bank of transformers.

The insulation used on the suspension strings on the special line towers consists of sixteen 5-inch units instead of the standard eighteen units used on the balance of the line except on the towers next to the switchyard structure where thirteen units are used with grading rings set to give a 56-inch gap.

Corresponding gaps are installed

on each of the suspension strings on the transformer leads at the transformer structure.

Relay Protective System

A complete relay protective system for the generating and transformer stations has been provided with the following characteristics. It is co-ordinated with the system arrangement and relaying of the Niagara 220- and 110-kv. system of the Hydro-Electric Power Commission of Ontario and the generating stations associated therewith so as to form a successful operating system. This requires complete instantaneous zone protection for the Chats Falls equipment and circuits, directional stopped-range impedance distance protection on the 220-kv. lines, and suitably timed back-up protection to operate in case of failure of the instantaneous protection to function completely. Relay settings, ranges and times are suitable for such co-ordination. The complete relay system is installed so as to promote security from accidental or improper operation, to ensure certainty of correct operation and to facilitate testing and maintenance.

The relay system is divided into eight main features, some of which are sub-divided, as follows:—

Feature No. 1—Generator protection.

Feature No. 2—Transformer protection.

Feature No. 3—220-kv. line protection.

Feature No. 4—Generator standby protection.

Feature No. 5—Transformer standby protection.

Feature No. 6—220-kv. bus protection.

Feature No. 7—Station service protection.

Feature No. 8—Annunciator system.

The various relays for each feature are installed close to the equipment to be protected. Due to this fact, the current transformer secondary differential loops are of minimum length and are well balanced as to resistance.

Each individual relay is equipped with an operation indicator and the operation of each feature is announced automatically in the control room by a distinctive light and a general alarm bell. For features that trip breakers, an annunciator plate is provided, hinged to one end of the control and meter board, on which is engraved the single line diagram of the generating and transformer stations with small lights to represent each relay feature.

A separate annunciator system, in the control room, indicates the operation of relays which do not trip breakers and the failure of voltage to the line relays, to the 250-volt d.c. relay bus and to the generator lubricating oil pumps. This also includes indication of various mechanical troubles such as failure of oil pressure, water pressure and abnormal bearing temperature. The signals pertaining to generator troubles are duplicated by a small annunciator at each generator.

The relays installed for the generator and transformer differential protections are of the instantaneous ratio differential type. A voltage timer incorporated in the transformer relays

prevents faulty tripping when energizing the transformers. In case of a sudden drop in voltage, there is sufficient contact opening time lag in this timer to permit proper operation of the relay for transformer faults. These relays will operate in approximately one cycle.

The 220-kv. line relaying is of the directional distance type for phase-to-phase and phase-to-ground faults. The phase-to-phase protection contains a directional element and an instantaneous distance element with a range extending as near to the remote end of the line as is possible without actually being effective for terminal faults. This protection is selective with some margin with the instantaneous relaying of the terminal station. The phase-to-ground protection contains a directional element, a ground distance instantaneous element and a ground distance timed element. A test device is also provided which gives temporary instantaneous non-directional protection for the total length of the line while it is being energized or tested. There are three primary phase-to-phase and three primary phase-to-ground relays on each line, each relay having an individual annunciator light in the control room indicating on which phase the fault has occurred.

The distance and directional relays require sources of potential which are proportional, with sufficient accuracy, to the 220-kv. line phase-to-phase and phase-to-ground voltages. These are provided by condenser bushing potential devices operated from the bushings of the 220-kv. circuit breakers. There are two circuit breakers per line connection, either one or both of which may be used. A voltage selector relay automatically supplies potential to the line relays from the devices of the breaker carrying the line. In case of failure of a device itself, the selector relay transfers to the other set of devices. Normal operation is, of course, with both breakers closed.

The standby relays of features No. 4 and No. 5 are impedance distance type with an instantaneous element and a timed element, the contacts of which are in series and with a directional element the contact of which is blocked closed.

The relays for the 220-kv. bus protection are low range instantaneous overcurrent type, there being two sets of relays for each bus, connected to separate sets of current transformers to act as a duplicate protection. These relays operate through their respective auxiliary trip relays connected in series to guard against improper operation.

The station service transformers are protected by instantaneous overcurrent relays set at a current slightly exceeding that which can be obtained by a dead short circuit on the low voltage of the transformers and by a low energy type relay with geared contacts for ordinary overcurrents. The latter are set to be selective with low voltage feeder relays.

Telephone and Signal Systems

A manually-operated telephone switchboard is incorporated in the operator's desk in the control room. The Commission's lines from its Niagara and Madawaska systems, the line from the Gatineau Power Company, and thirty local lines

around the plant and from the operators' settlement are centralized at this switchboard. Isolating transformers are inserted in all circuits which extend beyond the station ground mat.

Two signal systems are provided, one for calls within the power house and the other for remote outside points. The former consists of a vacuum operated two-tone horn and a large annunciator in the generator room on which are denoted the numbers of the eight units. Code signals are given on the horn by a key on the operator's desk. Separate keys control the unit designations on the annunciator so that the floorman may be despatched to any desired machine.

The outside signal system comprises five motor-driven horns, one located on each of the four stop log sluiceways and the fifth on the power house roof. These are controlled by keys on the operator's desk and are audible from any point within a mile radius from the power house.

OIL SYSTEMS

There are four oil systems each comprising storage, filtering and handling equipment. One system is for the generator lubricating oil and three systems are for the insulating oils.

The generator lubricating oil system consists of individual motor driven pumping units at each generator. An oil reservoir is provided in each generator sufficient to provide gravity lubrication for the time required to replace a pumping unit in the event of failure. For replacing oil in any of the generators and for purifying the oil, two 1,200-gallon tanks and a special pressure filter equipped with an oil pumping unit the same as those at the generators are installed on the first gallery. The oil is handled from a generator to the storage and filtering equipment by flexible hose connecting to separate pipe lines for the used and filtered oil.

Each of the three insulating oil systems consists of a filter and sufficient storage capacity to empty any piece of electrical equipment which it serves and to hold sufficient good oil for replacement. One system is located on the second gallery of the power house for the 13.2-kv. and service equipments. Another system is located adjacent to the 220-kv. switchyard for the 220-kv. oil circuit breakers, and the third system for the transformers has the filtering equipment in the pump house, and the storage tanks located outside adjacent to the power house and transformers.

There is a total of 245,000 Imperial gallons of insulating oil in the various equipments of which amount the 13.2-k.v. equipment requires 5,000 gallons, the power transformers 118,000 gallons, and 220-kv. oil circuit breakers 122,000 gallons.

OPERATORS' HOUSES

Permanent accommodation for the operating staff has been provided by the construction of six brick houses on a site adjoining the village of Fitzroy Harbour. Water supply, electric power and telephone service are available to these houses. The site has been laid out for sixteen houses.

Operating Costs of Transformer Losses

By A. J. Magley, Chief Engineer, Moloney Electric Co. of Canada, Limited, Toronto.

THE physical principle of electro-magnetic induction is the basis of the design and operation of commercial alternating current power circuits. This principle is the first fundamental of the generator, transformer, motors, and most meters and relays.

Whenever alternating current flows through a circuit there is set up an alternating magnetic circuit linking with the electrical circuit. Energy is required to set up the magnetic circuit or field, but most of this energy is returned to the circuit twice each cycle as the magnetic field collapses to a neutral or zero state. This magnetic field is manifested in line inductance, the rotating field of an induction motor, the alternating magnetism of a transformer core, etc. The current to produce this magnetic field may be considered as a separately generated component, superimposed on the load or working current. Since this magnetising component of current is one-quarter cycle out of phase with the working current, the resultant or sum of the currents is some larger value than the working current, and at some time-phase difference from it. It is this phenomenon which complicates an otherwise comparatively simple problem by introducing such unwelcome considerations as exciting current, power factor, and reactance.

A brief analysis of transformer loss characteristics is herewith presented, so that workable values may be assigned in proper relation to arrive at a solution of costs or a comparison of costs during operation.

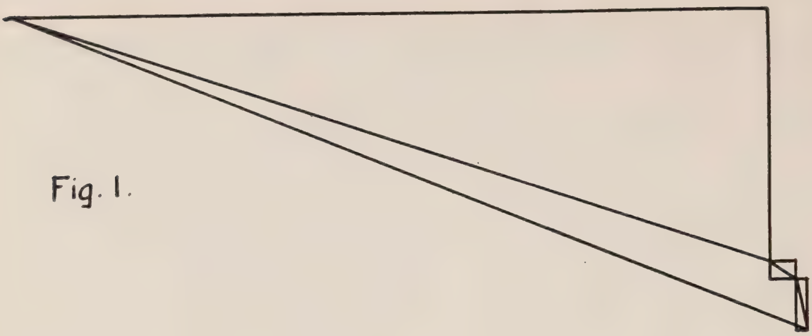
Transformer losses may be divided into two classes:

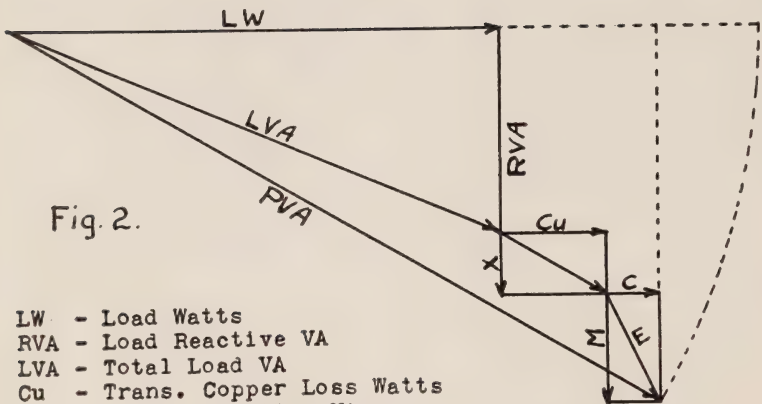
I. Energy losses
  1. Core loss
  2. Load losses.
    (a) Copper
    (b) Stray

II. Non-energy losses
  1. Magnetizing
  2. Reactive.

Core loss is a constant and continuous loss and independent of any secondary load that may be on the transformer. Load losses, often designated as copper loss, include both copper and various stray losses. Commonly defined, load loss is the tested wattmeter loss when one complete winding of the transformer is short circuited and sufficient voltage is applied to the other winding to produce rated current flow in both windings. This loss varies in proportion to the square of the load. With a rise in temperature the copper loss increases and the stray loss decreases.

The exciting current is the resultant or sum of the true energy core loss current, and the magnetizing current, which last is completely wattless. Exciting current, like core loss, is constant in value in constant potential systems.





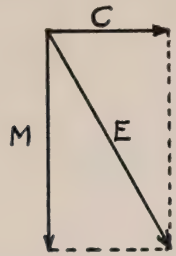
LW - Load Watts
RVA - Load Reactive VA
LVA - Total Load VA
Cu - Trans. Copper Loss Watts
X - Trans. Reactive VA
C - Trans. Core Loss Watts
M - Trans. Magnetizing VA
E - Trans. Exciting VA
PVA - Primary VA

Fig. 1. Scaled diagram of 5 KVA transformer Load 75% PF 95% Core loss 0.8% Copper 2.5% X 1.5% Exc. Cur. 5%

Fig. 2. Diagram not to scale with transformer characteristics enlarged for explanation.

When current flows in the windings of a transformer, some of the core magnetism linking both coils is diverted to such a path as not to completely link both coils. This results in a reduction of the secondary voltage and is termed the reactive drop. The reactive volt amperes are likewise wattless. Reactance is usually expressed in per cent., and reactive volt-amperes are proportional to the square of the load.

Given a certain secondary load and power factor, the required primary power characteristics will be the sum of the load and the transformer losses. To the energy of the load must be added the energy losses of the transformer, or load watts plus core loss plus transformer load loss, to give



Values of Magnetizing Component (M) in percent, given Exciting Current (E) in percent and Core Loss (C) in percent.

E	CORE LOSS 0.5	0.6	0.8	1.0	1.2
1.5	1.414	1.376	1.269	1.119	.900
2.0	1.936	1.905	1.833	1.732	1.600
2.5	2.449	2.429	2.368	2.291	2.193
3.0	2.958	2.939	2.891	2.828	2.749
3.5	3.464	3.448	3.407	3.353	3.287
4.0	3.968	3.954	3.919	3.873	3.815
6.0	5.979	5.970	5.946	5.916	5.878
8.0	7.983	7.977	7.960	7.937	7.909
10.	9.987	9.982	9.968	9.950	9.926
12	11.989	11.984	11.973	11.958	11.931
15	14.991	14.988	14.979	14.967	14.952
18	17.992	17.990	17.982	17.972	17.960

Reactive Component (X) at various power factors P.F.

PF	X	PF	X
100	0	87.5	48.412
97.5	22.220	85	52.678
95	31.224	80	60.000
92.5	37.996	75	66.144
90	43.588	70	71.414

primary watts. The primary reactive volt amperes is the sum of the r.v-a. (reactive volt-amperes) of the load plus the volt amperes of the magnetizing current plus the volt amperes of the transformer reactance. The sum of primary watts and primary r.v-a. with due respect to their phase relation (i.e., at right angles) is the total primary volt amperes. The primary power factor is of course the ratio of primary watts to primary volt-amperes.

In general there are two ways of charging for power. First: An energy consumption charge with penalty for

POWER FACTOR 100 LOAD 100 REACTANCE 1.5 Table I.

RKVA LOAD - 0 RKVA X - 1.50 All Values in Percent.

PRIMARY
--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	102.5	102.6	102.8	103.0	103.2
Cu @ 3.0	103.5	103.6	103.8	104.0	104.2
Cu @ 4.0	104.5	104.6	104.8	105.0	105.2

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	102.57	99.93	102.66	99.93	102.85	99.94	103.05	99.95	103.25	99.95
	3	103.57	99.93	103.66	99.93	103.85	99.94	104.05	99.95	104.25	99.95
	4	104.58	99.93	104.67	99.93	104.85	99.94	105.05	99.95	105.25	99.95
2.5	2	102.58	99.92	102.68	99.92	102.88	99.93	103.07	99.93	103.27	99.94
	3	103.57	99.92	103.67	99.92	103.87	99.93	104.07	99.93	104.27	99.94
	4	104.57	99.92	104.67	99.92	104.86	99.93	105.06	99.93	105.26	99.94
3	2	102.60	99.90	102.70	99.90	102.89	99.91	103.09	99.91	103.29	99.92
	3	103.60	99.90	103.70	99.90	103.89	99.91	104.09	99.91	104.29	99.92
	4	104.59	99.90	104.69	99.90	104.89	99.91	105.09	99.91	105.29	99.92
3.5	2	102.62	99.88	102.72	99.88	102.91	99.89	103.11	99.89	103.31	99.89
	3	103.62	99.88	103.72	99.88	103.91	99.89	104.11	99.89	104.31	99.89
	4	104.62	99.88	104.72	99.88	104.91	99.89	105.11	99.89	105.31	99.89
4	2	102.64	99.86	102.74	99.86	102.94	99.86	103.14	99.87	103.34	99.87
	3	103.64	99.85	103.74	99.86	103.94	99.86	104.14	99.87	104.34	99.87
	4	104.64	99.86	104.74	99.86	104.94	99.86	105.14	99.87	105.33	99.87
6	2	102.77	99.75	102.87	99.75	103.06	99.75	103.26	99.75	103.46	99.75
	3	103.77	99.74	103.87	99.75	104.06	99.75	104.26	99.75	104.46	99.75
	4	104.77	99.74	104.87	99.74	105.06	99.75	105.26	99.75	105.46	99.75
8	2	102.94	99.57	103.04	99.57	103.23	99.58	103.43	99.58	103.63	99.58
	3	103.94	99.58	104.03	99.58	104.23	99.58	104.43	99.58	104.62	99.58
	4	104.94	99.58	105.03	99.58	105.23	99.58	105.43	99.58	105.62	99.58
10	2	103.14	99.38	103.24	99.38	103.43	99.39	103.63	99.39	103.83	99.39
	3	104.13	99.38	104.23	99.39	104.43	99.39	104.63	99.39	104.83	99.39
	4	105.13	99.39	105.23	99.39	105.42	99.40	105.62	99.40	105.82	99.40
12	2	103.38	99.16	103.48	99.16	103.67	99.17	103.87	99.17	104.07	99.17
	3	104.37	99.18	104.47	99.17	104.66	99.18	104.86	99.18	105.06	99.18
	4	105.37	99.18	105.47	99.18	105.66	99.18	105.85	99.19	106.05	99.19
15	2	103.82	98.74	103.92	98.74	104.11	98.75	104.30	98.76	104.50	98.77
	3	104.81	98.74	104.91	98.74	105.10	98.75	105.29	98.76	105.49	98.78
	4	105.80	98.77	105.89	98.77	106.08	98.79	106.28	98.79	106.48	98.79
18	2	104.33	98.25	104.43	98.26	104.62	98.28	104.82	98.27	105.02	98.28
	3	105.32	98.27	105.42	98.28	105.61	98.28	105.80	98.29	106.00	98.29
	4	106.30	98.30	106.40	98.29	106.59	98.32	106.78	98.32	106.98	98.32

low power factor. Second: Charge for kv-a. used directly. Either method is an attempt to cover the additional cost of added current, rated generating and transmission equipment necessary because of customers consumption of energy at less than unity power factor.

It is less our purpose to evaluate the cost of transformer losses in dollars and cents (although that provision is included) than to provide a facility of comparison between transformers of varying characteristics in

POWER FACTOR 100 LOAD 90 REACTANCE 1.5 Table II

RKVA LOAD - 0 RKVA X - 1.215 All Values in Percent.

PRIMARY
--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	92.12	92.22	92.42	92.62	92.82
Cu @ 3.0	92.93	93.03	93.23	93.43	93.63
Cu @ 4.0	93.74	93.84	94.04	94.24	94.44

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	92.175	99.94	92.273	99.94	92.469	99.94	92.666	99.94	92.863	99.94
	3	92.984	99.94	93.082	99.94	93.278	99.94	93.475	99.95	93.672	99.95
	4	93.794	99.94	93.892	99.94	94.088	99.94	94.285	99.94	94.482	99.94
2.5	2	92.194	99.92	92.292	99.92	92.489	99.92	92.686	99.92	92.883	99.92
	3	93.003	99.92	93.101	99.92	93.298	99.93	93.495	99.94	93.692	99.94
	4	93.813	99.92	93.911	99.92	94.107	99.92	94.304	99.93	94.501	99.93
3	2	92.215	99.90	92.313	99.90	92.510	99.90	92.707	99.90	92.905	99.90
	3	93.025	99.90	93.123	99.90	93.320	99.91	93.517	99.91	93.714	99.92
	4	93.834	99.90	93.932	99.90	94.129	99.91	94.326	99.91	94.523	99.91
3.5	2	92.240	99.88	92.338	99.88	92.535	99.88	92.732	99.89	92.929	99.89
	3	93.049	99.87	93.147	99.88	93.344	99.89	93.541	99.89	93.738	99.89
	4	93.858	99.88	93.956	99.88	94.153	99.88	94.350	99.88	94.547	99.89
4	2	92.267	99.84	92.365	99.84	92.562	99.85	92.759	99.86	92.956	99.86
	3	93.075	99.84	93.173	99.84	93.370	99.85	93.567	99.86	93.765	99.86
	4	93.884	99.84	93.982	99.84	94.179	99.85	94.376	99.85	94.574	99.85
6	2	92.401	99.70	92.499	99.70	92.696	99.70	92.893	99.71	93.091	99.71
	3	93.209	99.69	93.307	99.69	93.504	99.70	93.701	99.71	93.898	99.72
	4	94.017	99.70	94.115	99.70	94.312	99.70	94.509	99.71	94.706	99.72
8	2	92.579	99.51	92.677	99.51	92.873	99.51	93.070	99.52	93.267	99.52
	3	93.385	99.51	93.483	99.51	93.680	99.52	93.877	99.52	94.074	99.52
	4	94.191	99.52	94.289	99.52	94.486	99.52	94.683	99.52	94.880	99.54
10	2	92.799	99.28	92.897	99.28	93.093	99.28	93.289	99.28	93.486	99.29
	3	93.603	99.27	93.701	99.27	93.897	99.29	94.094	99.29	94.291	99.30
	4	94.408	99.28	94.506	99.29	94.702	99.29	94.898	99.31	95.095	99.32
12	2	93.063	98.98	93.160	98.98	93.355	98.99	93.550	99.00	93.746	99.01
	3	93.865	98.99	93.962	98.99	94.157	99.01	94.352	99.01	94.548	99.03
	4	94.667	99.01	94.764	99.01	94.959	99.03	95.155	99.03	95.351	99.05
15	2	93.536	98.48	93.633	98.49	93.827	98.50	94.022	98.51	94.217	98.52
	3	94.333	98.51	94.430	98.52	94.625	98.52	94.820	98.53	95.015	98.55
	4	95.132	98.53	95.229	98.55	95.424	98.55	95.619	98.56	95.814	98.57
18	2	94.102	97.87	94.199	97.90	94.392	97.92	94.586	97.92	94.780	97.93
	3	94.895	97.91	94.992	97.94	95.185	97.95	95.379	97.97	95.573	97.97
	4	95.688	97.93	95.785	97.97	95.979	97.99	96.173	98.00	96.367	98.01

relation to the load which they serve. This facility is presented in the form of tables which give the solutions of total primary watts, primary volt-amperes, and primary power factor at certain designated secondary loads, power factors, and transformer characteristics all expressed in percentages of transformer rating.

Solutions are for any combination of the following variables:

Secondary power factor—100%, 95%, 90%, 80%.

Secondary loads — 100%, 90%,

POWER FACTOR 100 LOAD 75 REACTANCE 1.5 Table III.

RKVA LOAD - 0 RKVA X .844 All Values in Percent.

PRIMARY
--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	76.625	76.725	76.925	77.125	77.325
Cu @ 3.0	77.187	77.287	77.487	77.687	77.887
Cu @ 4.0	77.750	77.850	78.050	78.250	78.450

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	76.676	99.94	76.774	99.94	76.970	99.94	77.167	99.95	77.364	99.95
	3	77.238	99.94	77.336	99.94	77.532	99.94	77.729	99.95	77.925	99.95
	4	77.801	99.93	77.899	99.94	78.095	99.95	78.291	99.95	78.488	99.95
2.5	2	76.697	99.92	76.795	99.92	76.991	99.92	77.198	99.92	77.385	99.92
	3	77.258	99.92	77.356	99.92	77.552	99.92	77.749	99.92	77.946	99.92
	4	77.821	99.90	77.919	99.91	78.115	99.92	78.312	99.92	78.509	99.93
3	2	76.720	99.88	76.818	99.88	77.014	99.89	77.211	99.89	77.408	99.90
	3	77.282	99.88	77.380	99.88	77.576	99.89	77.773	99.89	77.970	99.90
	4	77.844	99.87	77.942	99.87	78.138	99.88	78.335	99.89	78.532	99.90
3.5	2	76.747	99.85	76.845	99.85	77.041	99.85	77.238	99.86	77.435	99.86
	3	77.308	99.85	77.406	99.85	77.602	99.85	77.799	99.86	77.996	99.86
	4	77.870	99.85	77.968	99.85	78.165	99.85	78.362	99.86	78.559	99.87
4	2	76.777	99.81	76.875	99.81	77.071	99.82	77.268	99.82	77.465	99.82
	3	77.338	99.81	77.436	99.81	77.632	99.82	77.829	99.82	78.026	99.82
	4	77.900	99.81	77.998	99.81	78.194	99.82	78.391	99.82	78.588	99.83
6	2	76.929	99.61	77.027	99.61	77.223	99.62	77.420	99.62	77.617	99.63
	3	77.489	99.61	77.587	99.61	77.783	99.62	77.980	99.62	78.177	99.63
	4	78.050	99.61	78.148	99.61	78.344	99.62	78.540	99.63	78.737	99.64
8	2	77.132	99.34	77.230	99.34	77.426	99.35	77.622	99.35	77.819	99.36
	3	77.693	99.35	77.789	99.35	77.985	99.36	78.181	99.37	78.377	99.38
	4	78.252	99.36	78.348	99.36	78.544	99.37	78.740	99.38	78.937	99.38
10	2	77.388	99.02	77.485	99.02	77.680	99.03	77.875	99.03	78.071	99.04
	3	77.945	99.02	78.042	99.03	78.237	99.04	78.432	99.05	78.628	99.06
	4	78.500	99.03	78.599	99.04	78.794	99.05	78.990	99.06	79.186	99.07
12	2	77.893	98.63	77.790	98.64	77.984	98.65	78.178	98.66	78.373	98.67
	3	78.247	98.65	78.344	98.65	78.538	98.66	78.733	98.68	78.928	98.69
	4	78.803	98.66	78.900	98.67	79.094	98.68	79.288	98.69	79.483	98.70
15	2	78.244	97.93	78.341	97.94	78.534	97.95	78.728	97.97	78.922	97.98
	3	78.795	97.96	78.892	97.97	79.085	97.98	79.279	97.99	79.473	98.00
	4	79.349	97.99	79.444	98.00	79.637	98.02	79.830	98.03	80.024	98.04
18	2	78.907	97.12	79.003	97.12	79.195	97.14	79.387	97.16	79.579	97.17
	3	79.453	97.16	79.549	97.16	79.741	97.18	79.933	97.20	80.125	97.22
	4	80.000	97.20	80.096	97.21	80.288	97.23	80.480	97.26	80.672	97.27

75%, 50%, 25%.

Core loss — 0.5%, 0.6%, 0.8% 1.0%, 1.2%.

Copper loss—2.0%, 3.0%, 4.0%.

Exciting current—2%, 2.5%, 3%, 3.5%, 4%, 6%, 8%, 10%, 12%, 15%, 18%.

Reactance—1.5%.

The above variables, in the opinion of the writer, cover the range of losses likely to be encountered in distribution systems of common voltages and

POWER FACTOR 100 LOAD 50 REACTANCE 1.5 Table IV.

RKVA LOAD - 0 RKVA X - .375 All Values in Percent.

PRIMARY
--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	51.00	51.10	51.30	51.50	51.70
Cu @ 3.0	51.25	51.35	51.55	51.75	51.95
Cu @ 4.0	51.50	51.60	51.80	52.00	52.20

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	51.053	99.90	51.151	99.90	51.346	99.92	51.542	99.92	51.738	99.93
	3	51.303	99.90	51.401	99.90	51.596	99.92	51.792	99.92	51.988	99.93
	4	51.552	99.90	51.650	99.90	51.845	99.91	52.041	99.92	52.237	99.93
2.5	2	51.079	99.85	51.177	99.85	51.372	99.85	51.568	99.85	51.764	99.85
	3	51.329	99.85	51.427	99.85	51.622	99.86	51.817	99.87	52.013	99.87
	4	51.578	99.85	51.676	99.85	51.871	99.86	52.067	99.88	52.263	99.88
3	2	51.109	99.79	51.207	99.79	51.402	99.80	51.598	99.81	51.794	99.82
	3	51.359	99.79	51.457	99.79	51.652	99.80	51.847	99.82	52.043	99.82
	4	51.608	99.79	51.706	99.79	51.901	99.80	52.097	99.82	52.293	99.82
3.5	2	51.145	99.72	51.243	99.72	51.438	99.73	51.634	99.74	51.830	99.75
	3	51.394	99.72	51.492	99.72	51.687	99.74	51.883	99.75	52.079	99.76
	4	51.643	99.72	51.741	99.72	51.936	99.75	52.132	99.75	52.328	99.76
4	2	51.185	99.64	51.283	99.64	51.478	99.65	51.674	99.66	51.870	99.67
	3	51.434	99.64	51.532	99.64	51.727	99.66	51.923	99.67	52.119	99.68
	4	51.683	99.64	51.781	99.65	51.976	99.66	52.172	99.67	52.368	99.68
6	2	51.393	99.23	51.492	99.23	51.687	99.25	51.882	99.26	52.077	99.28
	3	51.644	99.24	51.741	99.24	51.935	99.26	52.130	99.27	52.325	99.28
	4	51.892	99.24	51.989	99.25	52.183	99.26	52.378	99.28	52.573	99.29
8	2	51.681	98.68	51.778	98.69	51.972	98.70	52.166	98.72	52.360	98.74
	3	51.928	98.69	52.025	98.70	52.218	98.72	52.412	98.74	52.606	98.76
	4	52.175	98.71	52.272	98.72	52.466	98.73	52.660	98.75	52.854	98.77
10	2	52.043	98.00	52.139	98.01	52.331	98.03	52.523	98.06	52.716	98.08
	3	52.288	98.01	52.384	98.03	52.576	98.06	52.768	98.08	52.961	98.10
	4	52.533	98.03	52.629	98.05	52.821	98.08	53.014	98.10	53.207	98.12
12	2	52.481	97.19	52.576	97.20	52.765	97.23	52.954	92.27	53.144	97.30
	3	52.724	97.21	52.819	97.23	53.008	97.27	53.198	97.30	53.388	97.32
	4	52.967	97.24	53.062	97.26	53.251	97.29	53.441	97.32	53.631	97.34
15	2	53.265	95.75	53.359	95.76	53.547	95.80	53.735	95.84	53.924	95.87
	3	53.505	95.79	53.599	95.81	53.787	95.84	53.975	95.88	54.164	95.91
	4	53.744	95.82	53.838	95.85	54.026	95.88	54.215	95.91	54.404	95.94
18	2	54.208	94.08	54.300	94.10	54.485	94.16	54.670	94.20	54.855	94.25
	3	54.443	94.13	54.535	94.16	54.720	94.21	54.905	94.26	55.091	94.30
	4	54.679	94.19	54.771	94.21	54.956	94.26	55.141	94.31	55.326	94.36

of transformers 100 kv-a. and smaller.

In all there are solutions for 3,300 combinations. The value of 1.5 per cent. for reactance in all of the solutions was selected as representing the average value as the result of experience. Corrections for variations from this value are likely to be so small as to be negligible.

Explanation of the use of the tables follows herewith by the solution of a few representative examples:

POWER FACTOR 100 LOAD 25 REACTANCE 1.5 Table V.

RKVA LOAD - 0 RKVA X - .0938 All Values in Percent.

PRIMARY --- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	25.625	25.725	25.925	26.125	26.325
Cu @ 3.0	25.687	25.787	25.987	26.187	26.387
Cu @ 4.0	25.750	25.850	26.050	26.250	26.450

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	25.705	99.68	25.803	99.69	25.993	99.73	26.187	99.77	26.379	99.80
	3	25.767	99.69	25.865	99.70	26.056	99.74	26.250	99.77	26.442	99.80
	4	25.829	99.70	25.927	99.70	26.118	99.74	26.312	99.77	26.504	99.80
2.5	2	25.750	99.52	25.848	99.53	26.038	99.56	26.232	99.60	26.424	99.63
	3	25.813	99.51	25.911	99.52	26.101	99.56	26.295	99.59	26.486	99.63
	4	25.875	99.52	25.973	99.53	26.163	99.57	26.357	99.60	26.549	99.63
3	2	25.806	99.30	25.903	99.31	26.094	99.35	26.288	99.38	26.478	99.42
	3	25.868	99.30	25.965	99.32	26.156	99.35	26.350	99.38	26.540	99.42
	4	25.930	99.31	26.027	99.32	26.218	99.36	26.412	99.39	26.602	99.43
3.5	2	25.870	99.06	25.968	99.07	26.158	99.12	26.351	99.15	26.541	99.19
	3	25.932	99.06	26.030	99.07	26.220	99.12	26.413	99.15	26.603	99.19
	4	25.993	99.07	26.091	99.08	26.281	99.13	26.474	99.16	26.665	99.20
4	2	25.944	98.78	26.038	98.81	26.231	98.84	26.424	98.88	26.613	98.92
	3	26.006	98.78	26.100	98.81	26.293	98.84	26.486	98.88	26.675	98.92
	4	26.068	98.79	26.162	98.82	26.355	98.85	26.548	98.88	26.737	98.93
6	2	26.337	97.31	26.430	97.35	26.617	97.42	26.807	97.47	26.994	97.52
	3	26.398	97.32	26.491	97.36	26.678	97.42	26.868	97.47	27.055	97.53
	4	26.458	97.34	26.551	97.37	26.738	97.43	26.928	97.49	27.116	97.53
8	2	26.867	95.38	26.961	95.42	27.145	95.50	27.331	95.59	27.515	95.67
	3	26.927	95.40	27.021	95.43	27.205	95.52	27.391	95.60	27.574	95.69
	4	26.987	95.41	27.081	95.45	27.265	95.54	27.451	95.62	27.634	95.71
10	2	27.536	93.07	27.628	93.13	27.806	93.25	27.988	93.35	28.167	93.47
	3	27.594	93.10	27.686	93.15	27.865	93.27	28.047	93.38	28.226	93.49
	4	27.652	93.13	27.744	93.18	27.923	93.30	28.105	93.41	28.284	93.52
12	2	28.330	90.46	28.419	90.52	28.593	90.67	28.770	90.81	28.941	90.96
	3	28.387	90.49	28.476	90.56	28.650	90.71	28.827	90.85	28.998	91.00
	4	28.443	90.53	28.532	90.60	28.706	90.75	28.883	90.89	29.055	91.04
15	2	29.735	86.18	29.820	86.27	29.985	86.46	30.154	86.64	30.326	86.81
	3	29.789	86.24	29.874	86.32	30.040	86.51	30.209	86.69	30.381	86.85
	4	29.843	86.29	29.928	86.37	30.092	86.57	30.259	86.75	30.430	86.90
18	2	31.364	81.71	31.445	81.82	31.602	82.04	31.762	82.26	31.921	82.47
	3	31.415	81.78	31.496	81.88	31.654	82.10	31.814	82.32	31.973	82.53
	4	31.466	81.84	31.547	81.95	31.705	82.17	31.865	82.38	32.024	82.60

(A) What is the annual cost of power at $35 per annual kv-a. to supply a secondary load from a 5 kv-a. transformer at 95 per cent. p.f. and 75 per cent. load factor if the core loss is 40 watts, copper loss 100 watts, and exciting current 4 per cent.? Reduced to per cent. the core loss is 0.8 per cent. and copper loss is 2.0 per cent. From

POWER FACTOR 95 LOAD 100 REACTANCE 1.5 Table VI.

RKVA LOAD 31.224 RKVA X - 1.50 All Values in Percent.

PRIMARY
--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	97.5	97.6	97.8	98.0	98.2
Cu @ 3.0	98.5	98.6	98.8	99.0	99.2
Cu @ 4.0	99.5	99.6	99.8	100.0	100.2

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	103.47	94.22	103.55	94.24	103.72	94.28	103.87	94.34	104.03	94.38
	3	104.42	94.32	104.50	94.35	104.67	94.39	104.82	94.45	104.97	94.50
	4	105.37	94.42	105.45	94.45	105.62	94.49	105.77	94.55	105.92	94.60
2.5	2	103.65	94.05	103.73	94.07	103.90	94.12	104.06	94.17	104.22	94.20
	3	104.59	94.18	104.68	94.20	104.85	94.22	105.01	94.27	105.17	94.32
	4	105.54	94.28	105.62	94.30	105.79	94.33	105.95	94.38	106.11	94.43
3	2	103.81	93.91	103.90	93.93	104.07	93.98	104.24	94.01	104.41	94.05
	3	104.76	94.02	104.85	94.03	105.02	94.08	105.19	94.12	105.35	94.16
	4	105.70	94.13	105.79	94.15	105.96	94.18	106.13	94.22	106.29	94.26
3.5	2	103.99	93.74	104.08	93.77	104.25	93.81	104.42	93.86	104.59	93.92
	3	104.94	93.86	105.03	93.87	105.20	93.91	105.37	93.95	105.53	93.99
	4	105.87	93.99	105.96	93.99	106.13	94.02	106.30	94.06	106.47	94.12
4	2	104.16	93.60	104.25	93.61	104.43	93.64	104.60	93.68	104.78	93.71
	3	105.11	93.71	105.20	93.71	105.38	93.75	105.55	93.79	105.72	93.83
	4	106.05	93.82	106.14	93.83	106.31	93.87	106.48	93.90	106.65	93.95
6	2	104.89	92.95	104.98	92.96	105.16	93.00	105.33	93.04	105.51	93.07
	3	105.83	93.07	105.92	93.08	106.10	93.11	106.27	93.16	106.45	93.18
	4	106.76	93.19	106.85	93.21	107.03	93.22	107.20	93.27	107.38	93.30
8	2	105.65	92.28	105.74	92.29	105.92	92.33	106.10	92.36	106.27	92.41
	3	106.58	92.41	106.67	92.43	106.85	92.46	107.03	92.49	107.20	92.53
	4	107.51	92.55	107.60	92.56	107.78	92.60	107.96	92.63	108.13	92.67
10	2	106.43	91.58	106.52	91.60	106.70	91.64	106.88	91.68	107.06	91.71
	3	107.36	91.74	107.45	91.75	107.63	91.79	107.81	91.82	107.98	91.85
	4	108.28	91.89	108.37	91.91	108.55	91.94	108.73	91.97	108.90	92.02
12	2	107.25	90.89	107.34	90.90	107.52	90.94	107.70	90.98	107.88	91.01
	3	108.17	91.06	108.26	91.07	108.44	91.10	108.62	91.14	108.79	91.18
	4	109.08	91.21	109.17	91.23	109.35	91.26	109.53	91.30	109.70	91.34
15	2	108.54	89.82	108.63	89.84	108.80	89.88	108.98	89.92	109.16	89.96
	3	109.45	90.00	109.54	90.01	109.71	90.05	109.89	90.09	110.06	90.13
	4	110.35	90.16	110.44	90.18	110.61	90.22	110.79	90.26	110.96	90.30
18	2	109.89	88.72	109.98	88.74	110.15	88.79	110.33	88.82	110.51	88.86
	3	110.79	88.89	110.88	88.92	111.05	88.97	111.23	89.00	111.40	89.04
	4	111.68	89.08	111.77	89.10	111.94	89.14	112.12	89.19	112.29	89.23

Table VIII the primary total kv-a. is 78.414 per cent. whereas the secondary kv-a. used by the customer is 75 per cent. of 5 kv-a. The annual cost is 78.414 % × 5 × \$35 or \$137.27.

The loss in the transformer is therefore 78.414 per cent − 75 per cent. or 3.414 per cent of kv-a. or 170.7 v-a. which at \$35 per kv-a.

POWER FACTOR 95 LOAD 90 REACTANCE 1.5 Table VII.

RKVA LOAD - 28.1016 RKVA X - 1.215 All Values in Percent.

PRIMARY KW LOAD

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	87.62	87.72	87.92	88.12	88.32
Cu @ 3.0	88.43	88.53	88.73	88.93	89.13
Cu @ 4.0	89.24	89.34	89.54	89.74	89.94

PRIMARY KVA and POWER FACTOR

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	93.027	94.21	93.111	94.22	93.274	94.27	93.427	94.32	93.571	94.39
	3	93.790	94.29	93.874	94.30	94.039	94.35	94.194	94.41	94.340	94.48
	4	94.555	94.38	94.639	94.40	94.804	94.45	94.959	94.51	95.106	94.57
2.5	2	93.200	94.02	93.288	94.04	93.455	94.08	93.616	94.13	93.772	94.18
	3	93.962	94.11	94.050	94.13	94.218	94.17	94.380	94.22	94.536	94.28
	4	94.725	94.20	94.813	94.22	94.981	94.26	95.144	94.31	95.301	94.37
3	2	93.376	93.84	93.463	93.86	93.634	93.90	93.799	93.95	93.961	94.00
	3	94.136	93.94	94.223	93.95	94.395	93.99	94.561	94.04	94.723	94.10
	4	94.898	94.04	94.985	94.05	95.157	94.10	95.323	94.14	95.485	94.19
3.5	2	93.550	93.67	93.639	93.69	93.812	93.73	93.981	93.77	94.146	93.81
	3	94.310	93.76	94.399	93.78	94.572	93.82	94.741	93.87	94.906	93.92
	4	95.070	93.87	95.159	93.89	95.332	93.93	95.501	93.97	95.667	94.01
4	2	93.730	93.48	93.818	93.50	93.992	93.54	94.163	93.55	94.330	93.62
	3	94.487	93.59	94.575	93.61	94.750	93.65	94.922	93.69	95.089	93.74
	4	95.246	93.70	95.334	93.72	95.509	93.75	95.681	93.79	95.848	93.84
6	2	94.462	92.76	94.551	92.78	94.730	92.82	94.902	92.86	95.074	92.90
	3	95.214	92.88	95.303	92.90	95.483	92.94	95.655	92.98	95.827	93.02
	4	95.967	93.00	96.056	93.02	96.236	93.06	96.408	93.10	96.581	93.14
8	2	95.229	92.01	95.319	92.02	95.495	92.07	95.671	92.11	95.845	92.15
	3	95.975	92.15	96.065	92.16	96.242	92.20	96.418	92.25	96.592	92.29
	4	96.722	92.28	96.812	92.30	96.989	92.34	97.165	92.38	97.339	92.42
10	2	96.031	91.24	96.121	91.26	96.297	91.30	96.472	91.34	96.646	91.38
	3	96.771	91.38	96.861	91.40	97.038	91.44	97.213	91.48	97.387	91.52
	4	97.511	91.52	97.601	91.54	97.778	91.58	97.954	91.62	98.129	91.66
12	2	96.868	90.46	96.957	90.48	97.133	90.52	97.307	90.56	97.477	90.61
	3	97.601	90.60	97.690	90.62	97.867	90.66	98.042	90.71	98.212	90.76
	4	98.336	90.75	98.425	90.77	98.602	90.81	98.777	90.85	98.947	90.90
15	2	98.186	89.25	98.274	89.26	98.449	89.30	98.621	89.35	98.793	89.40
	3	98.909	89.40	98.997	89.42	99.173	89.47	99.346	89.51	99.518	89.56
	4	99.634	89.57	99.722	89.59	99.898	89.63	100.07	89.68	100.24	89.72
18	2	99.575	88.00	99.663	88.02	99.849	88.07	100.00	88.12	100.17	88.18
	3	100.29	88.17	100.38	88.20	100.55	88.24	100.71	88.29	100.89	88.34
	4	101.00	88.36	101.09	88.38	101.26	88.43	101.42	88.48	101.60	88.52

annual charge amounts to $5.97. The proportion of v-a. lost in the transformer to that delivered to the service equals 3.414 ÷ 75 or 4.55 per cent.

By the same table the primary power factor is 93.31 per cent. although the p.f. of the load is 95 per cent.

(B) What is the annual cost of

POWER FACTOR 95 LOAD 75 REACTANCE 1.5 Table VIII.

RKVA LOAD - 23.418 RKVA X - .844 All Values in Percent.

PRIMARY
--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	72.875	72.975	73.175	73.375	73.575
Cu @ 3.0	73.437	73.537	73.737	73.937	74.137
Cu @ 4.0	74.000	74.100	74.300	74.500	74.700

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	77.442	94.11	77.525	94.13	77.689	94.20	77.843	94.26	77.988	94.33
	3	77.971	94.18	78.054	94.20	78.219	94.27	78.374	94.34	78.519	94.41
	4	78.501	94.27	78.584	94.29	78.750	74.35	78.906	74.42	79.052	94.49
2.5	2	77.616	93.90	77.702	93.92	77.871	93.97	78.033	94.02	78.187	94.08
	3	78.144	93.98	78.230	94.00	78.399	94.06	78.561	94.12	78.715	94.18
	4	78.673	74.06	78.759	94.08	78.928	94.14	79.091	94.20	79.246	94.26
3	2	77.793	93.69	77.880	93.70	78.051	93.75	78.216	93.81	78.376	93.87
	3	78.320	93.76	78.407	93.79	78.578	93.84	78.744	93.89	78.904	93.95
	4	78.848	93.85	78.935	93.87	79.106	93.92	79.272	93.98	79.433	94.04
3.5	2	77.971	93.47	78.059	93.49	78.232	93.54	78.400	93.59	78.564	93.64
	3	78.497	93.55	78.585	93.57	78.758	93.62	78.926	93.68	79.090	93.74
	4	79.024	93.64	79.112	93.66	79.285	93.72	79.453	93.78	79.617	93.82
4	2	78.153	93.26	78.240	93.28	78.414	93.31	78.585	93.36	78.750	93.41
	3	78.677	93.33	78.764	93.36	78.939	93.41	79.110	93.46	79.275	93.52
	4	79.203	93.43	79.290	93.45	79.465	93.50	79.636	93.56	79.802	93.61
6	2	78.900	92.38	78.989	92.40	79.164	92.44	79.335	92.49	79.509	92.54
	3	79.420	92.47	79.509	92.49	79.685	92.53	79.856	92.59	80.030	92.64
	4	79.941	92.58	80.030	92.60	80.206	92.65	80.377	92.71	80.551	92.76
8	2	79.691	91.44	79.779	91.46	79.955	91.52	80.129	91.57	80.301	91.62
	3	80.205	91.56	80.293	91.58	80.470	91.63	80.644	91.68	80.816	91.74
	4	80.721	91.68	80.809	91.70	80.986	91.75	81.160	91.80	81.333	91.85
10	2	80.522	90.50	80.610	90.53	80.785	90.58	80.959	90.63	81.130	90.68
	3	81.031	90.63	81.119	90.65	81.295	90.70	81.469	90.75	81.640	90.80
	4	81.542	90.75	81.630	90.78	81.806	90.82	81.980	90.87	82.152	90.92
12	2	81.394	89.54	81.481	89.56	81.656	89.61	81.829	89.66	81.995	89.72
	3	81.898	89.67	81.985	89.69	82.160	89.75	82.333	89.80	82.500	89.86
	4	82.403	89.80	82.490	89.82	82.665	89.88	82.839	89.94	83.006	90.00
15	2	82.775	88.05	82.861	88.07	83.033	88.13	83.204	88.19	83.373	88.24
	3	83.270	88.19	83.356	88.21	83.529	88.28	83.700	88.34	83.869	88.40
	4	83.767	88.34	83.853	88.38	84.026	88.44	84.197	88.50	84.367	88.55
18	2	84.239	86.52	84.324	86.54	84.494	86.61	84.663	86.67	84.830	86.73
	3	84.726	86.67	84.811	86.70	84.981	86.77	85.150	86.83	85.317	86.89
	4	85.215	86.84	85.300	86.86	85.470	86.93	85.639	86.99	85.807	87.05

the same load from the same transformer but at 80 per cent. p.f. From Table XVIII the total primary kv-a. is 79.441 per cent. of 5 kv-a. and the annual cost is 79.441 % × 5 × \$35 or \$139.02.

The annual cost of the transformer losses to supply this load is (79.441 % − 75%) × 5 × \$35 or \$7.77.

POWER FACTOR 95 LOAD 50 REACTANCE 1.5 Table IX.

RKVA LOAD - 15.612 RKVA X - .375 All Values in Percent.

PRIMARY
--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	48.50	48.60	48.80	49.00	49.20
Cu @ 3.0	48.75	48.85	49.05	49.25	49.45
Cu @ 4.0	49.00	49.10	49.30	49.50	49.70

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	51.705	93.80	51.789	93.84	51.952	93.93	52.105	94.04	52.249	94.17
	3	51.940	93.85	52.024	93.90	52.187	94.00	52.340	94.10	52.484	94.22
	4	52.174	93.92	52.258	93.96	52.421	94.05	52.575	94.15	52.720	94.28
2.5	2	51.886	93.47	51.972	93.50	52.137	93.60	52.297	93.70	52.451	93.80
	3	52.120	93.53	52.206	93.58	52.372	93.67	52.532	93.75	52.686	93.87
	4	52.354	93.60	52.440	93.64	52.606	93.72	52.766	93.82	52.921	93.92
3	2	52.069	93.15	52.155	93.18	52.324	93.27	52.489	93.35	52.647	93.46
	3	52.302	93.21	52.388	93.25	52.557	93.34	52.722	93.42	52.880	93.52
	4	52.535	93.27	52.621	93.32	52.790	93.40	52.955	93.49	53.114	93.58
3.5	2	52.265	93.80	52.342	92.85	52.513	92.93	52.679	93.02	52.841	93.10
	3	52.487	92.88	52.574	92.92	52.745	93.00	52.911	93.10	53.073	93.18
	4	52.720	92.95	52.807	92.99	52.978	93.07	53.144	93.16	53.306	93.25
4	2	52.445	92.48	52.532	92.52	52.703	92.60	52.871	92.69	53.035	92.78
	3	52.676	92.54	52.763	92.59	52.935	92.68	53.103	92.76	53.267	92.85
	4	52.908	92.62	52.995	92.66	53.167	92.74	53.335	92.82	53.500	92.91
6	2	53.242	91.09	53.330	91.13	53.502	91.21	53.672	91.29	53.840	91.38
	3	53.470	91.16	53.558	91.21	53.730	91.30	53.900	91.38	54.068	91.46
	4	53.698	91.25	53.786	91.29	53.958	91.36	54.128	91.44	54.297	91.54
8	2	54.100	89.65	54.187	89.69	54.359	89.77	54.528	89.86	54.696	89.96
	3	54.324	89.74	54.411	89.78	54.584	89.86	54.753	89.95	54.921	90.04
	4	54.549	89.83	54.636	89.87	54.809	89.95	54.978	90.03	55.146	90.13
10	2	55.017	88.16	55.103	88.20	55.273	88.29	55.441	88.39	55.607	88.49
	3	55.238	88.26	55.324	88.30	55.494	88.40	55.662	88.50	55.828	88.59
	4	55.459	88.37	55.545	88.41	55.715	88.50	55.883	88.59	56.050	88.69
12	2	55.990	86.62	56.074	86.67	56.241	86.77	56.408	86.86	56.569	86.97
	3	56.207	86.73	56.291	86.77	56.459	86.87	56.626	86.97	56.787	87.08
	4	56.424	86.84	56.508	86.89	56.676	86.98	56.843	87.08	57.004	87.18
15	2	57.562	84.26	57.632	84.32	57.795	84.44	57.958	84.55	58.119	84.66
	3	57.773	84.38	57.843	84.46	58.007	84.58	58.170	84.68	58.331	84.79
	4	57.984	84.51	58.054	84.58	58.218	84.69	58.381	84.80	58.543	84.91
18	2	59.224	81.89	59.300	81.96	59.458	82.07	59.617	82.19	59.775	82.31
	3	59.429	82.03	59.505	82.09	59.664	82.21	59.823	82.32	59.981	82.44
	4	59.635	82.16	59.711	82.23	59.870	82.35	60.029	82.46	60.187	82.58

The p.f. on the primary side is 77.96 per cent.

(C) Suppose the same transformer is supplying a service where the peak demand is high but the average demand is low with a load factor of, say, 25 per cent. and 95 per cent. p.f. The annual cost of power is from Table X, 27.346 % × 5 × \$35 or \$47.86.

POWER FACTOR 95 LOAD 25 REACTANCE 1.5 Table X.

RKVA LOAD 7.806 RKVA X - .09375 All Values in Percent.

PRIMARY
--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	24.375	24.475	24.675	24.875	25.075
Cu @ 3.0	24.437	24.537	24.737	24.937	25.137
Cu @ 4.0	24.500	24.600	24.800	25.000	25.200

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	26.285	92.75	26.366	92.84	26.511	93.08	26.674	93.26	26.814	93.52
	3	26.343	92.77	26.424	92.87	26.570	93.12	26.733	93.28	26.873	93.55
	4	26.401	92.81	26.482	92.90	26.628	93.14	26.791	93.32	26.931	93.58
2.5	2	26.481	92.06	26.565	92.14	26.713	92.38	26.881	92.54	27.030	92.77
	3	26.539	92.09	26.623	92.17	26.771	92.41	26.939	92.58	27.088	92.80
	4	26.596	92.12	26.680	92.21	26.828	92.45	26.996	92.61	27.146	92.83
3	2	26.684	91.34	26.768	91.44	26.919	91.66	27.090	91.82	27.243	92.04
	3	26.741	91.38	26.825	91.47	26.976	91.70	27.147	91.86	27.300	92.31
	4	26.798	91.42	26.882	91.50	27.033	91.74	27.204	91.90	27.358	92.12
3.5	2	26.895	90.63	26.978	90.72	27.129	90.96	27.302	91.11	27.457	91.33
	3	26.951	90.67	27.034	90.76	27.186	90.99	27.359	91.15	27.514	91.36
	4	27.008	90.71	27.091	90.80	27.243	91.03	27.416	91.19	27.572	91.40
4	2	27.110	89.92	27.194	90.01	27.346	90.25	27.520	90.39	27.677	90.60
	3	27.167	89.96	27.251	90.05	27.403	90.28	27.577	90.43	27.733	90.64
	4	27.223	90.00	27.307	90.10	27.459	90.32	27.633	90.47	27.790	90.68
6	2	28.049	86.91	28.131	87.00	28.281	87.25	28.454	87.42	28.611	87.64
	3	28.104	86.95	28.186	87.05	28.336	87.30	28.509	87.47	28.666	87.66
	4	28.158	87.01	28.240	87.11	28.390	87.35	28.563	87.52	28.721	87.74
8	2	29.094	83.78	29.174	83.90	29.320	84.17	29.488	84.37	29.642	84.60
	3	29.146	83.84	29.226	83.97	29.373	84.22	29.541	84.42	29.695	84.66
	4	29.199	83.92	29.279	84.03	29.426	84.29	29.594	84.48	29.748	84.72
10	2	30.233	80.63	30.311	80.75	30.453	81.04	30.616	81.26	30.766	81.50
	3	30.284	80.70	30.362	80.82	30.504	81.10	30.667	81.32	30.817	81.58
	4	30.334	80.78	30.412	80.90	30.554	81.17	30.717	81.40	30.868	81.64
12	2	31.460	77.49	31.534	77.62	31.671	77.92	31.829	78.16	31.972	78.43
	3	31.508	77.57	31.582	77.70	31.720	77.99	31.878	78.23	32.021	78.51
	4	31.557	77.64	31.631	77.78	31.769	78.07	31.927	78.31	32.070	78.58
15	2	33.438	72.90	33.510	73.04	33.639	73.37	33.789	73.63	33.926	73.92
	3	33.484	72.98	33.556	73.13	33.685	73.45	33.835	73.71	33.972	74.00
	4	33.529	73.08	33.601	73.22	33.730	73.53	33.880	73.80	34.018	74.08
18	2	35.560	68.55	35.627	68.70	35.750	69.02	35.895	69.30	36.035	69.59
	3	35.603	68.63	35.670	68.79	35.793	69.11	35.938	69.39	36.078	69.68
	4	35.646	68.73	35.713	68.88	35.836	69.20	35.981	69.48	36.122	69.77

The cost of the losses is:

(27.346 % − 25%.) × 5 × \$35 or \$4.11.

This represents 2.346 ÷ 25 or 9.4 per cent. of the kv-a. supplied to the service.

The primary power factor is 90.25 per cent.

(D) If a 25 kv-a. transformer with 0.6 per cent. core loss, 2 per

POWER FACTOR 90 LOAD 100 REACTANCE 1.5 Table XI.

RKVA LOAD - 43.588 RKVA X - 1.50 All Values in Percent

PRIMARY
--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	92.50	92.60	92.80	93.00	93.20
Cu @ 3.0	93.50	93.60	93.80	94.00	94.20
Cu @ 4.0	94.50	94.60	94.80	95.00	95.20

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	103.77	89.14	103.84	89.17	103.99	89.24	104.12	89.32	104.24	89.40
	3	104.66	89.34	104.73	89.36	104.86	89.43	105.01	89.52	105.13	89.60
	4	105.56	89.53	105.63	89.55	105.78	89.62	105.91	89.70	106.03	89.78
2.5	2	104.00	88.94	104.08	88.97	104.23	89.03	104.38	89.10	104.51	89.18
	3	104.89	89.13	104.97	89.17	105.12	89.23	105.27	89.30	105.40	89.37
	4	105.78	89.33	105.86	89.36	106.01	89.42	106.16	89.48	106.30	89.55
3	2	104.23	88.74	104.31	88.77	104.47	88.84	104.62	88.90	104.76	88.97
	3	105.12	88.95	105.20	88.97	105.36	89.03	105.51	89.09	105.65	89.16
	4	106.01	89.13	106.09	89.16	106.25	89.22	106.40	89.28	106.54	89.35
3.5	2	104.46	88.55	104.55	88.57	104.70	88.64	104.86	88.69	105.01	88.75
	3	105.35	88.75	105.44	88.77	105.59	88.83	105.75	88.89	105.89	88.96
	4	106.23	88.95	106.32	88.97	106.47	89.04	106.63	89.09	106.79	89.14
4	2	104.70	88.35	104.78	88.37	104.94	88.43	105.10	88.49	105.25	88.55
	3	105.59	88.55	105.67	88.58	105.83	88.63	105.99	88.68	106.14	88.75
	4	106.48	88.74	106.56	88.77	106.72	88.83	106.88	88.88	107.03	88.94
6	2	105.66	87.53	105.74	87.55	105.90	87.62	106.07	87.67	106.23	87.72
	3	106.54	87.74	106.62	87.78	106.78	87.84	106.95	87.88	107.10	87.95
	4	107.42	87.97	107.50	88.00	107.66	88.06	107.83	88.11	107.98	88.16
8	2	106.64	86.72	106.73	86.73	106.89	86.80	107.05	86.86	107.21	86.92
	3	107.51	86.96	107.60	86.97	107.76	87.04	107.92	87.09	108.08	87.14
	4	108.38	87.18	108.47	87.21	108.63	87.26	108.79	87.32	108.96	87.37
10	2	107.66	85.90	107.74	85.93	107.90	86.00	108.07	86.05	108.23	86.10
	3	108.52	86.16	108.60	86.19	108.76	86.24	108.93	86.29	109.09	86.35
	4	109.38	86.40	109.46	86.43	109.62	86.49	109.79	86.53	109.95	86.59
12	2	108.68	85.11	108.77	85.14	108.93	85.19	109.10	85.24	109.26	85.30
	3	109.54	85.35	109.63	85.37	109.79	85.43	109.96	85.49	110.12	85.55
	4	110.39	85.60	110.48	85.62	110.64	85.68	110.81	85.72	110.97	85.79
15	2	110.30	83.86	110.38	83.88	110.54	83.95	110.71	84.00	110.86	84.07
	3	111.14	84.12	111.22	84.15	111.38	84.21	111.55	84.27	111.71	84.32
	4	111.98	84.38	112.06	84.41	112.22	84.47	112.39	84.52	112.55	84.58
18	2	111.96	82.60	112.04	82.62	112.20	82.70	112.36	82.76	112.52	82.82
	3	112.79	82.88	112.87	82.92	113.03	82.98	113.19	83.04	113.35	83.10
	4	113.62	83.17	113.70	83.20	113.86	83.25	114.02	83.31	114.18	83.37

cent. copper loss, and 10 per cent. exciting current supplying a 95 per cent. p.f. secondary load at 75 per cent. load factor is replaced by another 25 kv-a. transformer with 0.5 per cent. core loss, 2 per cent. copper loss, and 2.5 per cent. exciting current, what is the annual saving in transformer losses at $35 per kv-a. per annum?

POWER FACTOR 90 LOAD 90 REACTANCE 1.5 Table XII.

RKVA LOAD - 39.229 RKVA X - 1.215 All Values in Percent.

PRIMARY

--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	83.12	83.22	83.42	83.62	83.82
Cu @ 3.0	83.93	84.03	84.23	84.43	84.63
Cu @ 4.0	84.74	84.84	85.04	85.24	85.44

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	93.301	89.10	93.376	89.14	93.522	89.21	93.654	89.29	93.774	89.39
	3	94.023	89.27	94.098	89.30	94.245	89.38	94.378	89.46	94.498	89.55
	4	94.747	89.43	94.822	89.46	94.969	89.54	95.103	89.63	95.224	89.72
2.5	2	93.534	88.88	93.614	88.91	93.764	88.98	93.906	89.05	94.041	89.13
	3	94.255	89.05	94.335	89.08	94.486	89.14	94.629	89.22	94.764	89.30
	4	94.977	89.22	95.057	89.25	95.209	89.33	95.353	89.40	95.488	89.48
3	2	93.769	88.66	93.849	88.69	94.004	88.76	94.152	88.82	94.294	88.89
	3	94.488	88.83	94.568	88.86	94.724	88.93	94.873	89.00	95.015	89.07
	4	95.208	89.00	95.288	89.03	95.444	89.10	95.594	89.17	95.737	89.24
3.5	2	94.003	88.44	94.085	88.47	94.242	88.53	94.395	88.60	94.542	88.66
	3	94.721	88.61	94.803	88.64	94.961	88.70	95.114	88.77	95.261	88.84
	4	95.439	88.79	95.521	88.82	95.679	88.89	95.833	88.95	95.981	89.02
4	2	94.241	88.20	94.323	88.24	94.483	88.30	94.637	88.37	94.787	88.43
	3	94.956	88.39	95.038	88.42	95.199	88.49	95.354	88.55	95.504	88.61
	4	95.673	88.57	95.755	88.60	95.916	88.67	96.072	88.74	96.223	88.81
6	2	95.205	87.30	95.288	87.34	95.451	87.40	95.611	87.45	95.768	87.52
	3	95.913	87.50	95.996	87.53	96.160	87.59	96.321	87.65	96.478	87.72
	4	96.623	87.70	96.706	87.73	96.870	87.79	97.032	87.86	97.190	87.92
8	2	96.198	86.41	96.282	86.44	96.446	86.50	96.608	86.56	96.767	86.62
	3	96.899	86.62	96.983	86.65	97.148	86.70	97.310	86.77	97.469	86.83
	4	97.601	86.82	97.685	86.85	97.850	86.91	98.013	86.97	98.173	87.03
10	2	97.222	85.51	97.305	85.54	97.468	85.60	97.631	85.66	97.790	85.72
	3	97.916	85.72	97.999	85.74	98.163	85.80	98.326	85.86	98.485	85.92
	4	98.611	85.92	98.694	85.96	98.858	86.02	99.022	86.08	99.182	86.14
12	2	98.276	84.59	98.358	84.62	98.521	84.68	98.682	84.74	98.838	84.81
	3	98.962	84.81	99.044	84.84	99.208	84.90	99.370	84.96	99.526	85.03
	4	99.650	85.03	99.732	85.07	99.897	85.13	100.06	85.20	100.21	85.26
15	2	99.909	83.20	99.991	83.23	100.15	83.29	100.31	83.35	100.47	83.42
	3	100.59	83.42	100.67	83.46	100.83	83.52	100.99	83.58	101.15	83.66
	4	101.26	83.68	101.34	83.71	101.50	83.77	101.67	83.84	101.83	83.90
18	2	101.62	81.79	101.69	81.83	101.86	81.90	102.01	81.97	102.16	82.04
	3	102.27	82.06	102.34	82.09	102.51	82.15	102.67	82.22	102.83	82.28
	4	102.94	82.30	103.01	82.34	103.18	82.41	103.34	82.48	103.49	82.55

From Table VIII:

(80.610% − 77.616%) × 25 × \$35 or \$26.20 represents the annual saving.

The primary p.f. is improved from 90.53 per cent. to 93.90 per cent.

(E) Suppose the secondary is supplying a factory load of 80 per cent. p.f. and load factor of 50 per

POWER FACTOR 90 LOAD 75 REACTANCE 1.5 Table XIII.

RKVA LOAD - 32.691 RKVA X - .844 All Values in Percent.

PRIMARY
--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	69.125	69.225	69.425	69.625	69.825
Cu @ 3.0	69.687	69.787	69.987	70.187	70.387
Cu @ 4.0	70.250	70.350	70.550	70.750	70.950

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	77.695	88.99	77.770	89.02	77.915	89.12	78.048	89.21	78.167	89.33
	3	78.195	89.13	78.270	89.16	78.416	89.26	78.550	89.36	78.669	89.48
	4	78.698	89.26	78.773	89.30	78.919	89.40	79.053	89.50	79.173	89.62
2.5	2	77.931	88.72	78.010	88.75	78.159	88.84	78.301	88.92	78.435	89.02
	3	78.430	88.86	78.509	88.89	78.659	88.98	78.802	89.07	78.936	89.18
	4	78.931	89.00	79.010	89.04	79.160	89.12	79.303	89.22	79.438	89.32
3	2	78.166	88.45	78.246	88.49	78.400	88.57	78.549	88.65	78.690	88.74
	3	78.664	88.60	78.744	88.62	78.899	88.71	79.048	88.79	79.189	88.89
	4	79.163	88.74	79.243	88.77	79.398	88.86	79.548	88.94	79.690	89.04
3.5	2	78.404	88.18	78.485	88.22	78.642	88.29	78.793	88.37	78.939	88.46
	3	78.900	88.33	78.981	88.36	79.139	88.44	79.291	88.52	79.437	88.62
	4	79.398	88.48	79.479	88.52	79.637	88.60	79.789	88.68	79.936	88.78
4	2	78.643	87.91	78.724	87.95	78.883	88.02	79.038	88.10	79.187	88.18
	3	79.138	88.06	79.219	88.10	79.379	88.17	79.534	88.25	79.683	88.33
	4	79.634	88.21	79.715	88.26	79.875	88.33	80.031	88.41	80.181	88.50
6	2	79.621	86.82	79.704	86.85	79.865	86.94	80.025	87.02	80.180	87.10
	3	80.110	86.99	80.193	87.02	80.355	87.10	80.515	87.18	80.670	87.25
	4	80.600	87.16	80.683	87.19	80.845	87.26	81.005	87.34	81.161	87.42
8	2	80.636	85.74	80.718	85.78	80.881	85.85	81.040	85.93	81.193	86.01
	3	81.118	85.92	81.200	85.95	81.364	86.02	81.524	86.10	81.677	86.17
	4	81.603	86.08	81.685	86.12	81.849	86.20	82.009	86.28	82.162	86.36
10	2	81.685	84.64	81.767	84.68	81.929	84.75	82.089	84.82	82.246	84.90
	3	82.161	84.82	82.243	84.86	82.406	84.92	82.567	85.00	82.724	85.08
	4	82.640	85.00	82.722	85.04	82.885	85.12	83.046	85.20	83.203	85.27
12	2	82.769	83.52	82.850	83.56	83.011	83.64	83.171	83.72	83.323	83.80
	3	83.239	83.72	83.320	83.75	83.482	83.83	83.642	83.91	83.794	84.00
	4	83.711	83.92	83.792	83.96	83.955	84.04	84.115	84.12	84.268	84.20
15	2	84.457	81.86	84.539	81.90	84.696	81.98	84.852	82.07	85.008	82.15
	3	84.918	82.08	85.000	82.11	85.158	82.19	85.315	82.27	85.471	82.35
	4	85.381	82.27	85.463	82.31	85.621	82.39	85.778	82.48	85.935	82.56
18	2	86.217	80.18	86.296	80.23	86.452	80.31	86.606	80.40	86.760	80.48
	3	86.668	80.41	86.747	80.45	86.904	80.54	87.059	80.62	87.213	80.70
	4	87.121	80.63	87.200	80.66	87.357	80.76	87.513	80.85	87.668	80.94

cent. what would be the annual saving in cost of transformer losses by the exchange of transformers in (D)?

From Table XIX:

(57.601% − 52.519%) × 25 × \$35 or \$44.47 represents the annual saving in transformer losses.

The proportion of saving is (57.601 − 52.519) ÷ 57.601 or

POWER FACTOR 90 LOAD 50 REACTANCE 1.5 Table XIV.

RKVA LOAD 21.794 RKVA X .375 All Values in Percent.

PRIMARY
--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	46.00	46.10	46.30	46.50	46.70
Cu @ 3.0	46.25	46.35	46.55	46.75	46.95
Cu @ 4.0	46.50	46.60	46.80	47.00	47.20

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	51.933	88.58	52.007	88.64	52.151	88.78	52.282	88.94	52.401	89.13
	3	52.155	88.69	52.229	88.74	52.374	88.89	52.505	89.05	52.624	89.22
	4	52.378	88.78	52.452	88.84	52.597	88.99	52.728	89.14	52.847	89.32
2.5	2	52.173	88.16	52.252	88.22	52.399	88.36	52.540	88.51	52.672	88.67
	3	52.394	88.28	52.473	88.33	52.621	88.47	52.762	88.61	52.894	88.78
	4	52.615	88.38	52.694	88.44	52.842	88.58	52.983	88.72	53.116	88.88
3	2	52.418	87.76	52.497	87.82	52.648	87.94	52.792	88.08	52.932	88.23
	3	52.635	87.87	52.714	87.93	52.867	88.05	53.013	88.19	53.153	88.34
	4	52.855	87.98	52.934	88.04	53.087	88.16	53.233	88.30	53.374	88.45
3.5	2	52.659	87.35	52.739	87.41	52.893	87.53	53.043	87.66	53.187	87.81
	3	52.878	87.46	52.958	87.52	53.113	87.64	53.263	87.78	53.407	87.92
	4	53.097	87.58	53.177	87.63	53.332	87.76	53.482	87.89	53.627	88.02
4	2	52.906	86.95	52.987	87.01	53.140	87.12	53.289	87.26	53.433	87.39
	3	53.124	87.06	53.205	87.12	53.362	87.24	53.514	87.36	53.661	87.50
	4	53.342	87.17	53.423	87.22	53.580	87.35	53.732	87.47	53.879	87.61
6	2	53.928	85.30	54.009	85.36	54.169	85.47	54.324	85.60	54.476	85.72
	3	54.142	85.42	54.223	85.48	54.382	85.60	54.537	85.72	54.689	85.86
	4	54.366	85.53	54.447	85.59	54.603	85.71	54.755	85.84	54.904	85.97
8	2	55.001	83.63	55.072	83.70	55.240	83.81	55.395	83.94	55.548	84.08
	3	55.211	83.77	55.282	83.84	55.450	83.95	55.605	84.08	55.758	84.22
	4	55.421	83.91	55.492	83.98	55.660	84.09	55.815	84.21	55.969	84.34
10	2	56.135	81.95	56.204	82.02	56.360	82.15	56.513	82.28	56.665	82.42
	3	56.330	82.10	56.409	82.17	56.566	82.29	56.720	82.42	56.872	82.56
	4	56.546	82.23	56.615	82.31	56.772	82.44	56.926	82.56	57.078	82.71
12	2	57.295	80.29	57.373	80.35	57.526	80.49	57.678	80.62	57.825	80.76
	3	57.496	80.44	57.574	80.51	57.728	80.64	57.880	80.78	58.027	80.92
	4	57.697	80.60	57.775	80.66	57.929	80.80	58.081	80.93	58.229	81.06
15	2	59.134	77.79	59.210	77.86	59.360	78.00	59.509	78.14	59.656	78.28
	3	59.329	77.95	59.405	78.02	59.556	78.16	59.705	78.30	59.852	78.44
	4	59.524	78.12	59.600	78.19	59.751	78.32	59.900	78.46	60.048	78.60
18	2	61.064	75.33	61.139	75.40	61.286	75.55	61.430	75.70	61.573	75.84
	3	61.253	75.50	61.328	75.58	61.474	75.72	61.619	75.87	61.763	76.01
	4	61.442	75.68	61.517	75.76	61.662	75.90	61.808	76.04	61.953	76.18

8.83 per cent.

The primary p.f. is improved from 71.36 per cent. to 78.07 per cent.

(F) If in the foregoing (E) the transformers are loaded to load factor of 90 per cent. the annual saving effected by changing the transformer is from Table XVII: (98.789% − 93.907%) × 25 × \$35

POWER FACTOR 90 LOAD 25 REACTANCE 1.5 Table XV.

RKVA LOAD 10.897 RKVA X - .09375 All Values in Percent.

PRIMARY
--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	23.125	23.225	23.425	23.625	23.825
Cu @ 3.0	23.187	23.287	23.487	23.687	23.887
Cu @ 4.0	23.250	23.350	23.550	23.750	23.950

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	26.492	87.30	26.565	87.42	26.705	87.72	26.833	88.05	26.947	88.42
	3	26.547	87.34	26.620	87.48	26.760	87.78	26.888	88.10	27.003	88.46
	4	26.601	87.40	26.674	87.54	26.814	87.83	26.942	88.15	27.058	88.52
2.5	2	26.747	86.46	26.825	86.58	26.967	86.87	27.103	87.16	27.230	87.50
	3	26.801	86.51	26.879	86.64	27.021	86.92	27.157	87.22	27.284	87.54
	4	26.855	86.57	26.933	86.70	27.075	86.98	27.211	87.28	27.339	87.60
3	2	27.006	85.63	27.082	85.76	27.229	86.04	27.370	86.32	27.503	86.62
	3	27.060	85.69	27.136	85.82	27.283	86.09	27.424	86.37	27.557	86.68
	4	27.113	85.75	27.189	85.88	27.336	86.16	27.477	86.44	27.611	86.74
3.5	2	27.271	84.80	27.348	84.93	27.496	85.21	27.638	85.49	27.777	85.77
	3	27.324	84.86	27.401	85.00	27.549	85.27	27.692	85.54	27.831	85.83
	4	27.377	84.94	27.454	85.06	27.602	85.33	27.745	85.61	27.884	85.90
4	2	27.541	83.97	27.618	84.10	27.767	84.38	27.912	84.65	28.051	84.94
	3	27.594	84.03	27.671	84.17	27.820	84.44	27.965	84.71	28.104	85.00
	4	27.646	84.10	27.723	84.23	27.872	84.50	28.017	84.78	28.157	85.06
6	2	28.684	80.62	28.759	80.77	28.907	81.05	29.051	81.33	29.198	81.61
	3	28.734	80.70	28.809	80.84	28.957	81.12	29.102	81.40	29.249	81.67
	4	28.785	80.78	28.860	80.92	29.008	81.20	29.153	81.48	29.300	81.74
8	2	29.912	77.32	29.986	77.46	30.131	77.75	30.272	78.05	30.411	78.35
	3	29.961	77.40	30.035	77.54	30.180	77.84	30.321	78.12	30.460	78.42
	4	30.009	77.48	30.083	77.62	30.228	77.92	30.369	78.21	30.509	78.50
10	2	31.222	74.06	31.293	74.22	31.432	74.53	31.570	74.84	31.704	75.15
	3	31.269	74.16	31.340	74.31	31.479	74.62	31.617	74.93	31.751	75.23
	4	31.315	74.25	31.386	74.40	31.525	74.71	31.663	75.01	31.798	75.32
12	2	32.601	70.93	32.669	71.10	32.804	71.42	32.936	71.73	33.061	72.06
	3	32.645	71.02	32.713	71.19	32.848	71.51	32.981	71.82	33.106	72.15
	4	32.690	71.12	32.758	71.28	32.893	71.60	33.026	71.92	33.152	72.24
15	2	34.782	66.49	34.847	66.65	34.974	66.99	35.099	67.32	35.223	67.65
	3	34.824	66.58	34.889	66.75	35.016	67.08	35.141	67.41	35.265	67.74
	4	34.865	66.69	34.930	66.85	35.057	67.19	35.183	67.50	35.308	67.84
18	2	37.078	62.37	37.139	62.54	37.258	62.87	37.377	63.21	37.494	63.54
	3	37.117	62.47	37.178	62.64	37.297	62.97	37.416	63.31	37.534	63.64
	4	37.156	62.58	37.217	62.74	37.336	63.08	37.455	63.41	37.574	63.74

or $42.72.

The proportion of saving is: (98.789 − 93.907) ÷ 98.789 or 4.95 per cent.

The primary p.f. is improved from 75.12 per cent. to 78.92 per cent.

Many more examples might be given illustrating a great variety of solutions but we believe the foregoing

POWER FACTOR 80 LOAD 100 REACTANCE 1.5 Table XVI.

RKVA LOAD - 60.00 RKVA X - 1.50 All Values in Percent.

PRIMARY
--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	82.5	82.6	82.8	83.0	83.2
Cu @ 3.0	83.5	83.6	83.8	84.0	84.2
Cu @ 4.0	84.5	84.6	84.8	85.0	85.2

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	104.07	79.28	104.13	79.30	104.25	79.42	104.35	79.54	104.42	79.67
	3	104.86	79.63	104.92	79.68	105.04	79.77	105.14	79.88	105.22	80.02
	4	105.66	79.97	105.72	80.01	105.84	80.11	105.94	80.22	106.02	80.36
2.5	2	104.38	79.04	104.45	79.08	104.57	79.18	104.69	79.28	104.78	79.40
	3	105.17	79.40	105.24	79.43	105.36	79.53	105.48	79.62	105.58	79.74
	4	105.97	79.73	106.04	79.77	106.16	79.87	106.28	79.96	106.38	80.08
3	2	104.69	78.80	104.76	78.84	104.89	78.93	105.01	79.03	105.12	79.15
	3	105.48	79.16	105.55	79.20	105.68	79.29	105.80	79.38	105.91	79.49
	4	106.28	79.49	106.35	79.53	106.48	79.62	106.60	79.72	106.71	79.82
3.5	2	105.02	78.55	105.08	78.60	105.22	78.69	105.34	78.79	105.45	78.90
	3	105.80	78.92	105.86	78.96	106.00	79.04	106.12	79.14	106.24	79.24
	4	106.59	79.26	106.65	79.30	106.79	79.39	106.91	79.49	107.03	79.59
4	2	105.31	78.34	105.39	78.38	105.52	78.46	105.65	78.56	105.77	78.66
	3	106.11	78.69	106.18	78.72	106.31	78.82	106.44	78.90	106.56	79.00
	4	106.88	79.04	106.96	79.08	107.09	79.17	107.22	79.26	107.35	79.35
6	2	106.57	77.41	106.64	77.45	106.78	77.54	106.91	77.62	107.06	77.71
	3	107.36	77.77	107.43	77.81	107.57	77.88	107.71	77.98	107.84	78.07
	4	108.14	78.13	108.21	78.17	108.35	78.26	108.48	78.35	108.62	78.44
8	2	107.86	76.48	107.93	76.52	108.07	76.61	108.21	76.70	108.35	76.79
	3	108.63	76.87	108.70	76.91	108.84	77.00	108.98	77.08	109.13	77.15
	4	109.40	77.24	109.47	77.28	109.61	77.36	109.75	77.45	109.89	77.52
10	2	109.17	75.57	109.24	75.61	109.39	75.69	109.53	75.78	109.65	75.88
	3	109.92	75.96	109.99	76.00	110.14	76.08	110.28	76.16	110.41	76.25
	4	110.69	76.33	110.76	76.37	110.91	76.44	111.05	76.53	111.18	76.62
12	2	110.48	74.67	110.56	74.71	110.70	74.80	110.84	74.88	110.97	74.98
	3	111.23	75.06	111.31	75.10	111.45	75.18	111.59	75.26	111.72	75.35
	4	111.98	75.44	112.06	75.48	112.20	75.56	112.34	75.65	112.48	75.73
15	2	112.51	73.32	112.58	73.37	112.72	73.45	112.86	73.54	112.99	73.64
	3	113.24	73.73	113.31	73.78	113.45	73.86	113.59	73.95	113.73	74.03
	4	113.98	74.13	114.05	74.17	114.19	74.26	114.33	74.34	114.48	74.42
18	2	114.57	72.00	114.64	72.05	114.78	72.14	114.92	72.22	115.05	72.32
	3	115.29	72.42	115.36	72.46	115.50	72.54	115.64	72.62	115.77	72.72
	4	116.02	72.82	116.09	72.86	116.23	72.95	116.37	73.04	116.50	73.12

examples demonstrate the possibilities of the use of the tables. Since all values are given in per cent. and calculated from fundamental relations they are applicable to all sizes of transformers covered by the ranges of characteristics in the tables. Whether charges are based on kv-a. consumption or on kw. consumption with p.f. penalty the tables are equally applic-

POWER FACTOR 80 LOAD 90 REACTANCE 1.5 Table XVII.

RKVA LOAD 54.0 RKVA X - 1.215 All Values in Percent.

PRIMARY
--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	74.12	74.22	74.42	74.62	74.82
Cu @ 3.0	74.93	75.03	75.23	75.43	75.63
Cu @ 4.0	75.74	75.84	76.04	76.24	76.44

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	93.593	79.20	93.655	79.24	93.770	79.36	93.868	79.49	93.947	79.64
	3	94.236	79.51	94.298	79.56	94.414	79.68	94.513	79.81	94.593	79.96
	4	94.882	79.82	94.944	79.88	95.061	79.99	95.161	80.11	95.242	80.26
2.5	2	93.907	78.92	93.976	78.98	94.097	79.09	94.209	79.20	94.307	79.33
	3	94.548	79.25	94.617	79.30	94.738	79.41	94.851	79.53	94.950	79.66
	4	95.191	79.57	95.260	79.61	95.382	79.72	95.496	79.84	95.597	79.96
3	2	94.219	78.66	94.289	78.71	94.417	78.81	94.536	78.93	94.646	79.05
	3	94.858	78.99	94.928	79.03	95.057	79.14	95.177	79.26	95.288	79.38
	4	95.500	79.31	95.570	79.35	95.700	79.46	95.820	79.57	95.932	79.68
3.5	2	94.533	78.40	94.604	78.45	94.735	78.55	94.859	78.66	94.976	78.77
	3	95.170	78.73	95.241	78.78	95.373	78.88	95.498	78.99	95.616	79.10
	4	95.809	79.05	95.880	79.10	96.013	79.20	96.139	79.31	96.258	79.41
4	2	94.848	78.14	94.919	78.19	95.054	78.29	95.182	78.39	95.303	78.50
	3	95.482	78.48	95.553	78.52	95.689	78.62	95.818	78.72	95.940	78.83
	4	96.120	78.80	96.191	78.84	96.327	78.94	96.457	79.04	96.580	79.15
6	2	96.114	77.12	96.188	77.17	96.327	77.26	96.462	77.37	96.594	77.47
	3	96.741	77.47	96.815	77.51	96.955	77.60	97.091	77.70	97.223	77.80
	4	97.370	77.80	97.444	77.84	97.584	77.93	97.721	78.02	97.854	78.12
8	2	97.403	76.10	97.477	76.15	97.619	76.24	97.756	76.34	97.891	76.44
	3	98.021	76.45	98.095	76.50	98.238	76.59	98.376	76.69	98.512	76.78
	4	98.642	76.79	98.716	76.83	98.859	76.94	98.998	77.05	99.135	77.15
10	2	98.715	75.08	98.789	75.12	98.930	75.22	99.068	75.32	99.204	75.41
	3	99.325	75.44	99.399	75.49	99.541	75.59	99.680	75.68	99.816	75.77
	4	99.936	75.79	100.01	75.83	100.15	75.92	100.29	76.01	100.43	76.10
12	2	100.05	74.08	100.12	74.13	100.27	74.22	100.40	74.32	100.53	74.42
	3	100.65	74.44	100.72	74.49	100.87	74.59	101.00	74.69	101.14	74.78
	4	101.26	74.79	101.33	74.84	101.48	74.94	101.60	75.03	101.74	75.12
15	2	102.09	72.59	102.16	72.64	102.29	72.74	102.43	72.84	102.57	72.94
	3	102.68	72.97	102.75	73.01	102.89	73.11	103.03	73.21	103.17	73.31
	4	103.27	73.35	103.34	73.39	103.48	73.49	103.62	73.58	103.76	73.67
18	2	104.17	71.15	104.25	71.19	104.38	71.29	104.51	71.40	104.65	71.50
	3	104.75	71.52	104.83	71.57	104.96	71.67	105.10	71.77	105.24	71.86
	4	105.33	71.90	105.41	71.95	105.54	72.05	105.68	72.14	105.82	72.23

able. Where values between those given are required, straight line or proportional interpolation may be used and will be found of sufficient accuracy

Exception may be taken to the technology of some of the statements made or the nomenclature used but the intention of this exposition is to supply data useful to the average

POWER FACTOR 80 LOAD 75 REACTANCE 1.5 Table XVIII.

RKVA LOAD - 45.00 RKVA X - .84375 All Values in Percent.

PRIMARY
--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	61.625	61.725	61.925	62.125	62.325
Cu @ 3.0	62.187	62.287	62.487	62.687	62.887
Cu @ 4.0	62.750	62.850	63.050	63.250	63.450

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	77.977	79.03	78.038	79.10	78.152	79.24	78.249	79.39	78.328	79.57
	3	78.423	79.30	78.484	79.36	78.599	79.50	78.697	79.66	78.777	79.83
	4	78.870	79.56	78.931	79.63	79.047	79.76	79.146	79.92	79.227	80.10
2.5	2	78.293	78.71	78.351	78.78	78.480	78.90	78.590	79.05	78.689	79.20
	3	78.737	78.98	78.795	79.05	78.925	79.17	79.036	79.32	79.135	79.47
	4	79.182	79.25	79.240	79.32	79.371	79.44	79.483	79.57	79.583	79.73
3	2	78.608	78.40	78.675	78.45	78.803	78.58	78.932	78.71	79.030	78.86
	3	79.050	78.67	79.117	78.73	79.245	78.85	79.365	78.99	79.474	79.13
	4	79.494	78.93	79.561	78.99	79.689	79.12	79.810	79.26	79.920	79.40
3.5	2	78.924	78.08	78.992	78.15	79.123	78.27	79.246	78.40	79.362	78.54
	3	79.364	78.35	79.432	78.42	79.564	78.54	79.687	78.67	79.804	78.80
	4	79.806	78.63	79.874	78.69	80.006	78.81	80.129	78.94	80.248	79.07
4	2	79.245	77.76	79.308	77.83	79.441	77.96	79.568	78.08	79.690	78.21
	3	79.678	78.05	79.747	78.11	79.881	78.23	80.009	78.36	80.131	78.48
	4	80.118	78.33	80.187	78.39	80.321	78.50	80.450	78.63	80.573	78.76
6	2	80.519	76.54	80.590	76.60	80.728	76.72	80.862	76.84	80.991	76.97
	3	80.950	76.84	81.021	76.89	81.160	77.00	81.295	77.12	81.425	77.24
	4	81.383	77.11	81.454	77.17	81.593	77.28	81.729	77.40	81.860	77.51
8	2	81.822	75.31	81.894	75.37	82.034	75.49	82.169	75.61	82.303	75.72
	3	82.247	75.61	82.319	75.67	82.460	75.78	82.596	75.89	82.730	76.01
	4	82.673	75.90	82.745	75.96	82.886	76.07	83.023	76.18	83.158	76.30
10	2	83.155	74.11	83.226	74.16	83.386	74.27	83.523	74.38	83.634	74.52
	3	83.573	74.41	83.644	74.47	83.783	74.59	83.921	74.70	84.054	74.82
	4	83.992	74.72	84.063	74.77	84.203	74.89	84.340	75.00	84.470	75.12
12	2	84.512	72.92	84.582	72.99	84.720	73.10	84.856	73.22	84.984	73.35
	3	84.923	73.24	84.993	73.30	85.132	73.41	85.269	73.53	85.398	73.65
	4	85.336	73.54	85.406	73.60	85.545	73.71	85.683	73.82	85.813	73.95
15	2	86.593	71.17	86.663	71.22	86.800	71.34	86.935	71.46	87.067	71.58
	3	86.995	71.48	87.065	71.54	87.202	71.66	87.337	71.78	87.470	71.90
	4	87.398	71.80	87.468	71.86	87.605	71.97	87.741	72.09	87.875	72.21
18	2	88.728	69.46	88.796	69.52	88.930	69.64	89.062	69.76	89.193	69.88
	3	89.120	69.79	89.188	69.85	89.322	69.96	89.455	70.08	89.587	70.20
	4	89.514	70.11	89.582	70.16	89.716	70.29	89.850	70.40	89.983	70.52

power distribution superintendent with the more laborious mathematical work already completed.

Some of the conclusions which may be drawn from the foregoing examples or from a study of the tables are:

(1) The cost of transformer losses becomes proportionately less as the loading increases to the rating of the transformer.

POWER FACTOR 80 LOAD 50 REACTANCE 1.5 Table XIX.

RKVA LOAD - 30.00 RKVA X - .375 All Values in Percent.

PRIMARY
--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	41.00	41.10	41.30	41.50	41.70
Cu @ 3.0	41.25	41.35	41.55	41.75	41.95
Cu @ 4.0	41.50	41.60	41.80	42.00	42.20

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	52.202	78.54	52.261	78.64	52.373	78.85	52.469	79.10	52.548	79.36
	3	52.398	78.72	52.458	78.82	52.571	79.04	52.668	79.27	52.747	79.53
	4	52.594	78.91	52.655	79.00	52.769	79.22	52.867	79.44	52.946	79.70
2.5	2	52.519	78.07	52.586	78.16	52.705	78.36	52.814	78.58	52.911	78.82
	3	52.715	78.25	52.782	78.35	52.901	78.55	53.011	78.76	53.108	79.00
	4	52.911	78.44	52.978	78.53	53.097	78.73	53.208	78.94	53.306	79.16
3	2	52.840	77.60	52.906	77.69	53.032	77.88	53.148	78.09	53.255	78.31
	3	53.034	77.79	53.100	77.88	53.226	78.07	53.343	78.27	53.451	78.49
	4	53.229	77.98	53.295	78.07	53.421	78.25	53.538	78.45	53.647	78.66
3.5	2	53.161	77.14	53.228	77.22	53.356	77.41	53.477	77.61	53.591	77.82
	3	53.354	77.32	53.421	77.41	53.550	77.60	53.672	77.80	53.786	78.00
	4	53.548	77.51	53.615	77.60	53.745	77.78	53.867	77.98	53.981	78.18
4	2	53.483	76.67	53.551	76.76	53.682	76.94	53.806	77.14	53.924	77.33
	3	53.675	76.86	53.743	76.95	53.875	77.13	54.000	77.32	54.118	77.52
	4	53.868	77.04	53.936	77.13	54.069	77.32	54.194	77.50	54.312	77.70
6	2	54.795	74.83	54.865	74.91	54.999	75.10	55.130	75.28	55.256	75.46
	3	54.983	75.02	55.053	75.10	55.187	75.29	55.318	75.47	55.444	75.66
	4	55.171	75.22	55.241	75.30	55.375	75.48	55.507	75.67	55.634	75.86
8	2	56.145	73.03	56.215	73.12	56.350	73.30	56.481	73.48	56.609	73.67
	3	56.328	73.24	56.398	73.33	56.533	73.50	56.665	73.69	56.793	73.87
	4	56.511	73.44	56.581	73.53	56.716	73.71	56.849	73.88	56.978	74.06
10	2	57.533	71.27	57.601	71.36	57.734	71.54	57.865	71.72	57.992	71.91
	3	57.712	71.48	57.780	71.56	57.913	71.75	58.045	71.93	58.172	72.12
	4	57.891	71.69	57.959	71.78	58.093	71.95	58.225	72.14	58.353	72.32
12	2	58.955	69.55	59.021	69.64	59.153	69.82	59.281	70.01	59.403	70.20
	3	59.129	69.76	59.195	69.86	59.328	70.04	59.457	70.22	59.579	70.41
	4	59.304	69.98	59.370	70.07	59.503	70.25	59.633	70.43	59.755	70.62
15	2	61.148	67.06	61.213	67.15	61.340	67.34	61.467	67.52	61.591	67.71
	3	61.316	67.28	61.381	67.37	61.509	67.56	61.636	67.74	61.760	67.93
	4	61.485	67.50	61.550	67.59	61.678	67.78	61.805	67.96	61.930	68.14
18	2	63.406	64.67	63.470	64.76	63.593	64.95	63.714	65.14	63.837	65.33
	3	63.568	64.90	63.632	64.99	63.756	65.18	63.878	65.37	64.001	65.55
	4	63.730	65.12	63.794	65.22	63.919	65.40	64.042	65.58	64.165	65.76

(2) The cost of the losses are less as the power factor of the load approaches unity.

(3) High exciting current results in a material reduction in primary power factor particularly on services of low load factor and low power factor.

(4) Extending networks to take advantage of load diversity in

POWER FACTOR 80   LOAD 25   REACTANCE 1.5   Table XX.

RKVA LOAD 15.0   RKVA X .09375   All Values in Percent.

PRIMARY
--- KW LOAD ---

	Core - 0.5	0.6	0.8	1.0	1.2
Cu @ 2.0	20.625	20.725	20.925	21.125	21.325
Cu @ 3.0	20.687	20.787	20.987	21.187	21.387
Cu @ 4.0	20.750	20.850	21.050	21.250	21.450

--- PRIMARY KVA and POWER FACTOR ---

		Core 0.5		0.6		0.8		1.0		1.2	
E	Cu	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF	TKVA	PF
2	2	26.747	77.12	26.805	77.32	26.915	77.75	27.008	78.22	27.082	78.74
	3	26.795	77.21	26.853	77.41	26.963	77.83	27.056	78.30	27.131	78.83
	4	26.843	77.30	26.901	77.51	27.011	77.93	27.105	78.40	27.181	78.92
2.5	2	27.076	76.17	27.140	76.36	27.254	76.78	27.359	77.22	27.452	77.70
	3	27.124	76.27	27.188	76.46	27.302	76.88	27.407	77.31	27.500	77.78
	4	27.172	76.36	27.236	76.56	27.350	76.97	27.456	77.40	27.549	77.87
3	2	27.408	75.26	27.472	75.44	27.591	75.84	27.702	76.26	27.805	76.70
	3	27.456	75.34	27.520	75.53	27.639	75.94	27.750	76.35	27.853	76.80
	4	27.503	75.44	27.567	75.63	27.686	76.02	27.797	76.45	27.901	76.89
3.5	2	27.744	74.35	27.811	74.52	27.930	74.92	28.045	75.32	28.153	75.75
	3	27.791	74.44	27.858	74.62	27.977	75.02	28.092	75.42	28.201	75.84
	4	27.837	74.55	27.904	74.72	28.023	75.12	28.138	75.52	28.248	75.94
4	2	28.084	73.45	28.149	73.63	28.273	74.01	28.391	74.41	28.501	74.82
	3	28.130	73.55	28.195	73.72	28.319	74.11	28.437	74.51	28.548	74.92
	4	28.176	73.65	28.241	73.83	28.365	74.21	28.483	74.61	28.595	75.02
6	2	29.486	69.95	29.550	70.14	29.674	70.52	29.794	70.91	29.910	71.30
	3	29.530	70.06	29.594	70.24	29.718	70.62	29.838	71.05	29.954	71.40
	4	29.574	70.16	29.638	70.35	29.762	70.73	29.882	71.12	29.999	71.51
8	2	30.950	66.64	31.013	66.82	31.134	67.21	31.252	67.60	31.367	68.00
	3	30.992	66.75	31.055	66.94	31.176	67.32	31.294	67.70	31.410	68.10
	4	31.034	66.86	31.097	67.05	31.218	67.43	31.336	67.82	31.452	68.20
10	2	32.472	63.52	32.532	63.71	32.649	64.10	32.764	64.48	32.875	64.87
	3	32.512	63.63	32.572	63.82	32.689	64.21	32.804	64.59	32.915	64.98
	4	32.552	63.75	32.612	63.93	32.729	64.32	32.844	64.70	32.956	65.10
12	2	34.042	60.58	34.099	60.78	34.212	61.16	34.323	61.55	34.426	61.95
	3	34.080	60.70	34.137	60.90	34.250	61.28	34.361	61.66	34.464	62.06
	4	34.118	60.82	34.175	61.01	34.288	61.40	34.399	61.78	34.503	62.17
15	2	36.475	56.55	36.530	56.74	36.636	57.11	36.741	57.50	36.845	57.88
	3	36.511	56.66	36.566	56.85	36.672	57.23	36.777	57.61	36.881	58.00
	4	36.546	56.78	36.601	56.97	36.707	57.35	36.813	57.72	36.917	58.11
18	2	38.987	52.91	39.039	53.09	39.138	53.47	39.237	53.84	39.336	54.21
	3	39.021	53.02	39.073	53.20	39.172	53.58	39.271	53.95	39.370	54.33
	4	39.054	53.13	39.106	53.32	39.205	53.69	39.304	54.06	39.404	54.44

building up the load factor on transformers would most certainly result in saving in the cost of overall losses.

Read at Association of Municipal Electrical Utilities Convention at Windsor, Ont., June 23, 1933.

The Starting of Polyphase Induction Motors

from

The Electric Utility Viewpoint

By Wilson J. Wylie, Power Department, Toronto Hydro-Electric System

(*Presented to Association of Municipal Electrical Utilities at Windsor, June 22, 1933.*)

THE function of an electric utility is to make available to the public within the area it serves a continuous supply of electric energy having good voltage regulation and at a reasonable cost to the purchaser. A consideration of any one of these three requirements cannot be made without involving the other two. While the control of the above factors lies largely with the electric utility a measure of co-operation is needed from the purchaser of electric energy far in excess of that required in the exchange of other commodities. When a manufacturer buys coal, steel or other raw material and takes delivery of same, how he may decide to use these commodities does not intimately affect the vendor or other manufacturers who may have purchased similar material. The purchaser of electric energy, however, can, if he uses the energy in certain ways, so disturb the electric utility's supply system that other purchasers of energy will have cause for complaint. These complaints made to the electric utility by consumers regarding faulty service cannot be entirely eliminated. They can, however, be kept to a minimum if both parties will co-operate in matters relating to the supply and use of electric energy. It is always better policy to avoid conditions being set up which are liable to cause complaint than to endeavour to adjust such conditions after they have been established.

The rated capacity of transformer banks, distribution lines and service conductors installed by the electric utility to supply a load or load area is usually less than the total rating of the equipment to be supplied. This is due to the diversity which occurs between the maximum demands of each piece of equipment and also the maximum demand of different consumers.

Figure 1 shows a group of consumers engaged in various lines of manufacture indicating the number of motors in each plant, the rating of the largest motor, the total of the ratings of all the motors and also the maximum demand of the plant. It will be noted that in no case does the maximum demand equal the total of motor rating.

In general the greater the number of motors in a plant or group of plants, the greater the ratio between the electric utility's supply equipment and the total load. In determining the size of utility equipment to be installed the ratio of the equipment

CONSUMERS LOAD DATA — TYPICAL

CHARACTER OF PLANT	Installed Capacity in kw.	Maximum Demand in kw.	No. of Motors in Plant	H.P. of Largest Motor	REMARKS
Flour Mill........	727	680	7	250	2,300 V.—3ϕ Service
" "	263	99	24	40	550 V. " "
Bakery...........	78	37	13	40	" " "
Rope Works.......	70	44	4	50	" " "
Steel Fabrication...	1427	304	85	300	" " "
Textile...........	104	46	70	5	" " "
Paint and Varnish..	393	132	73	26	" " "
Stock Foods.......	117	39	11	25	" " "
Ladies Wear.......	47	25	6	2	" " "
Boiler Repair......	60	31	7	30	" " "
Stone Cutting......	291	120	15	60	" " "

Fig. 1.

to consumer's total load is worked out from past experience gained in the supplying of loads of a similar type and is usually based on integrated maximum demands over a stated time period. This permits the electric utility's supply equipment to be operated at the best possible efficiency and at its highest revenue producing rate which is reflected in the cost at which the energy can be sold to the user.

Between industrial plants as a group and individually in each plant the processes performed by electric motor drives vary from what may be termed delicate operations to rough operations. Present day production methods calling for a continuous flow from raw material to finished product require to a greater extent than in the past, that the utility's supply be of such a quality that the delicate operation can be performed with the least trouble from voltage variation affecting motor torques and speeds.

Another factor that is becoming increasingly important is the effect which sudden changes in voltage have on illumination. A large amount of effort has been expended by electric utilities and lighting equipment manufacturers to interest industrial consumers in better lighting for their plant. As the plant lighting is usually supplied from the same service as that supplying the power if good lighting conditions, are to be realized, this can only be accomplished by the elimination if possible of sudden voltage variation. Studies have been made by lighting specialists of the effect on illumination when sudden changes occur in the value of supply voltage, and measurements have been taken of the maximum variation in the voltage which can be allowed to take place instantaneously with no noticeable effect on lighting. Many factors enter into this problem but it was determined that instantaneous changes of voltage of a value greater

than two volts on 120 volt lighting circuits would produce a noticeable effect on illumination. It was concluded that changes in voltage of from 6 to 8 volts where these changes were instantaneous would be likely to cause complaint even if only occurring two or three times an hour. On the other hand gradual changes in voltage of a much larger value can be made with no noticeable effect.

Figure 2 indicates the per cent. lumens at corresponding voltage value. A 2 per cent. drop in voltage causes approximately 6 per cent. drop in lumens.

When large values of current are taken by a consumer, relative to the size of the utility's supply equipment, a considerable drop in voltage will result and if this is sufficient to disturb other consumers by its effect on the supply lines a remedy can be brought about in two ways. The utility can install larger equipment or the need for large values of current during short time periods in the consumer's plant can be eliminated. If the large values of current were required by the consumer for long periods of time then the utility would not hesitate to enlarge its equipment as this would obviously be an increase in load. Where they are of short duration, however, the installation of larger equipment would be a handicap on the utility as the average load and revenue return would not have been increased to any extent. Larger equipment if installed would call for an increase in capital investment.

The taking of heavy current values for short periods of time tends to cause trouble in other ways. Overload settings on service switches and other protective equipment may have to be higher than if more even load conditions prevailed thus reducing the safety factor. The contacts of switches and other equipment may be

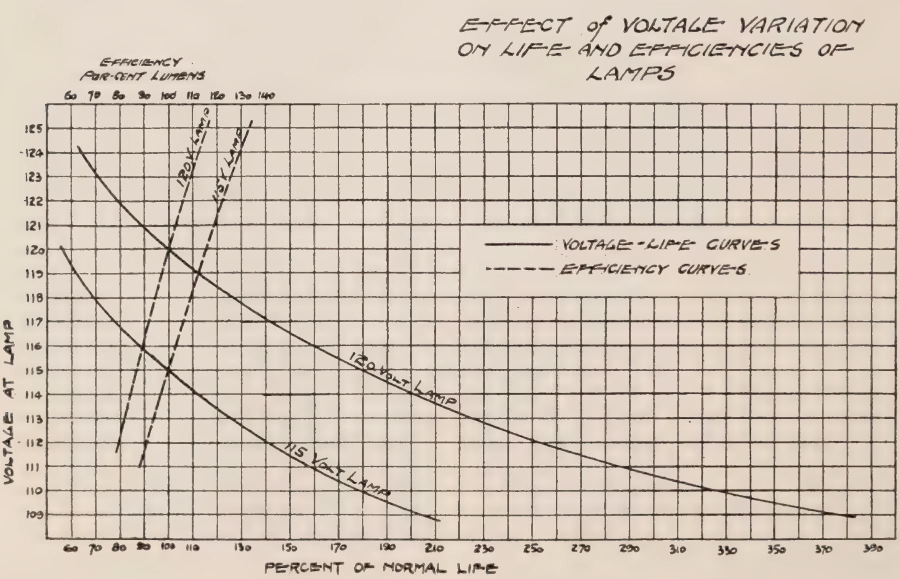


Fig. 2.

damaged due to the heavy current causing excessive heating. Again motors and other equipment are subject to increased dynamic stress which increases as the square of the current and unless constructed to withstand these stresses may fail.

It will be realized therefore that many valid reasons exist for the electric utility's request that motor starting equipment to be installed on a consumer's premises be subject to their reasonable approval.

The largest part of the industrial load on an electric utility's lines is made up of polyphase induction motors which have inherent qualities during their starting period causing them to require large values of current when compared with the current taken at rated load.

When an induction motor is connected to a point of electric energy supply having a potential equal to that for which the motor is designed, a current will flow for a few cycles in the stator windings and, therefore, in the supply lines having a value of from three to ten times that taken by the motor when it is carrying full load at its rated speed. This is due to the rotor of the motor being stationary when the potential is first applied, in effect similar to a transformer with a short-circuited secondary winding. The value of the voltage wave at the instant of closure of the starting switch has a bearing on the initial current which will result. The reason for this high value of current at start will be apparent when it is considered that the effect of the impedance of the stator and rotor when the rotor is stationary is considerably less than the effect of the counter electromotive force generated when the motor is running close to or at its rated speed. With the motor running close to synchronous speed the counter electromotive force nearly equals the applied electromotive force, therefore the current is small. It is these high values of current at the period of starting which often cause trouble on the electric utility lines.

Induction motors can be grouped into the following three general classes:—

(1) Standard Squirrel Cage Motors having a rotor winding of low resistance.

(2) Squirrel Cage Motors having one or two rotor windings of special design

(3) Induction Motors having phase wound rotors.

The motors within the first group constitute the largest portion of the induction motor load which the electric utilities supply. This type of motor is an efficient piece of electric equipment being well designed and rugged in construction. It has a good speed regulation and is suitable for drives where the starting duty is not heavy. From the electric utility viewpoint, however, two characteristics of this type of induction motor have to be considered. During the starting period values of current many times the rated full load current may be taken from the supply line. Unless the motor application is considered from this angle as well as its suitability for the drive requirements serious disturbances may be set up affecting other consumers. It might not be out of place to state in passing that this class of motor also has a low power factor at start and at light

loads so that care should be exercised in selecting a motor for a given duty. Too large a motor should not be chosen and with fluctuating loads full advantage should be taken of the overload rating of the motor.

The second group of induction motors in the above classification is being used in increasing numbers for duties having special requirements or where starting conditions make the installation of one of these motors desirable. The stator windings in most cases differ very little from those of the standard type. Various combinations, however, are used in the arrangement of the rotor windings to secure the characteristics desired. A single squirrel cage winding of high resistance alloy may be used or two squirrel cage windings may be installed in the rotor slots. Where two squirrel cage windings are used the outer cage is usually of high resistance alloy, while that in the bottom of the slot nearest the shaft is of lower resistance. The effect produced with the double squirrel cage arrangement is that when the rotor is stationary the magnetic fields set up by the stator windings are at line frequency, and as the inner squirrel cage bars are deeply imbedded in the rotor iron, a high reactance results which causes a large percentage of the current in the rotor to flow in the outer or high resistance cage. As the rotor speeds up the frequency of the field surrounding the rotor bars decreases until at rated speed the frequency may be two or three per second. At this relatively low frequency the reactance of the inner cage bars is very much reduced and as a result a large percentage of the current flows in the lower winding. By varying these combinations a fairly wide range of speed torque characteristics can be obtained. The different motor manufacturers employ their own methods of construction but the general arrangement is the same.

This type of motor is sometimes referred to as a "line start" or "full voltage starting" motor, due to the higher torque per ampere of current which is obtained. Another designation is "high reactance" or "high resistance and high reactance" squirrel cage motor depending on the design of the rotor cages. These motors can be designed for many drive requirements where high starting torques or particular speed torques are necessary and can also be designed for drives where a wide speed regulation is desirable.

The motors coming within the third group are the phase wound or wound rotor induction motors. As the name implies the rotor has phase windings in the rotor slots with the leads brought to slip rings on the rotor shaft or in some cases to terminals within the rotor itself. The slip ring type of phase wound induction motor can be equipped with external resistors which by a suitable controller are connected in series with the rotor circuits when the motor is started. As the motor attains speed the resistances are cut out of the rotor circuit in steps. Where the leads are taken to terminal block within the rotor spider self-contained resistances are mounted within the rotor, a centrifugal switch device being used to remove them from the rotor circuit.

This type of induction motor is suitable for heavy starting duty or

where a certain amount of speed control is desired. Due to the desirable starting characteristics possessed by the wound rotor motor when equipped with a suitable starting control electric utilities have in the past looked with a considerable amount of favour on this type of motor. Many utilities have adopted rules which call for a wound rotor motor to be installed where the rating of an induction motor exceeds a stated value. The Toronto Hydro-Electric System usually request that a wound rotor motor be installed where motors exceeding approximately 75 horsepower are to be used, unless some other type of motor can be equipped with starting control which will keep the maximum current from two to two and a half times the full load current.

The types of starting equipment used in conjunction with polyphase induction motors may for the purpose of this discussion be divided into the two following groups:

(1) Starters which during the starting of the motor disconnect the motor from the line for a short period of time after the motor has reached a percentage of its rated speed.

(2) Starters which do not disconnect the motor from the line after the motor has been energized.

The starters coming within the first group are the "auto transformer" or to give it its other name the "compensator starter" and the "Y delta" method of starting.

The "auto transformer" starter is used on the standard squirrel cage induction motors while the "Y delta" method requires a motor, the stator windings of which are especially arranged for this starting method.

The auto transformer starter is the most common type of starting equipment used for the starting of squirrel cage induction motors. It consists of an auto transformer taking current at line voltage and having suitable taps from which a reduced voltage can be applied to the motor terminal. When the motor has attained a percentage of its rated speed the full line voltage is applied to the stator winding. The change from reduced voltage to full line voltage is carried out by a double throw switch or by two interlocked switches. A tap on the transformers between the ranges of 50 per cent. to 85 per cent. of line voltage is usually selected to give the starting voltage. This type of starter is usually operated manually, the operator throwing the handle over to the starting position and holding it there for a short period of time before throwing over to the running position. The successful use of the auto transformer starter, therefore, depends to a considerable extent on the care of the operator. The reason for the wide use of this type of starter is that the current taken from the line at start is reduced below that which would be taken at full voltage by the selection of a suitable tap on the starting transformer. The lowest percentage tap is usually selected which will give sufficient voltage to start the motor. Assuming that a 50 per cent. tap was used the voltage applied to the motor terminals would be half of the line voltage and as the voltage has been reduced by one-half the current taken by the motor would also be one-half

of that at full voltage. As the energy input on the primary side of the transformer nearly equals the energy output on the secondary side with full line potential on the primary side of the transformer one-quarter of the current would be taken from the supply lines when compared with the current taken to start the motor at full voltage. Where higher taps are used higher voltages are applied to the motor terminals with a resulting high line current. The proper tap to select is determined by the torque requirements of the motor. While this is a relatively simple arrangement and quite effective in so far as reducing the line current is concerned there are two features which are not desirable from the electric utility viewpoint. During the changeover period from reduced voltage to full voltage the motor is disconnected from the line for a varying period of time, also when the switch is closed the second time in the running position conditions may exist within the motor circuits which will take large values of current until these conditions adjust themselves.

When an induction motor is running and is then disconnected from the lines, the magnetic fields in the motor tend to maintain the flow of current in the rotor winding. This persists for an appreciable time before dying out. The motor during this period is in effect a generator. When the starting switch is closed in the running position the E.M.F. generated in the motor may not be in phase with the line E.M.F., the result being that a heavy surge of current is taken from the line.

Certain difficulties may also be experienced due to the operator using poor judgment or not realizing just how long he should allow the motor to continue in the starting position. Should he not allow the required time to elapse and throw over to the running position before the motor has reached its maximum speed on the starting position, larger values of current will be taken from the line than if the changeover is made at the correct instant. For these reasons the auto transformer is a starting device which is somewhat uncertain in the results that are produced. When properly applied and operated the auto transformer method of starting is usually satisfactory. Its limitations, however, have to be kept in mind and it is not favoured for the larger induction motors.

Figure 3 is an oscillogram showing the starting of a 25 cycle three-phase 208 volt squirrel cage induction motor equipped with an auto transformer starter. The first surge of current at the moment of energizing the motor does not show as the oscillograph had not begun to operate. An interesting point, however, is that the operator in this case made two attempts before finally closing the switch in the running position and as shown on the oscillogram relatively large values of current were taken. It has been determined during investigations made on this subject that values of current as high as ten times rated full load current may result at the throw-over period. If this is repeated many times a day it may cause considerable damage to switch contacts, may operate low voltage trip mechanism and cause annoyance and complaint due to the effect on lighting.

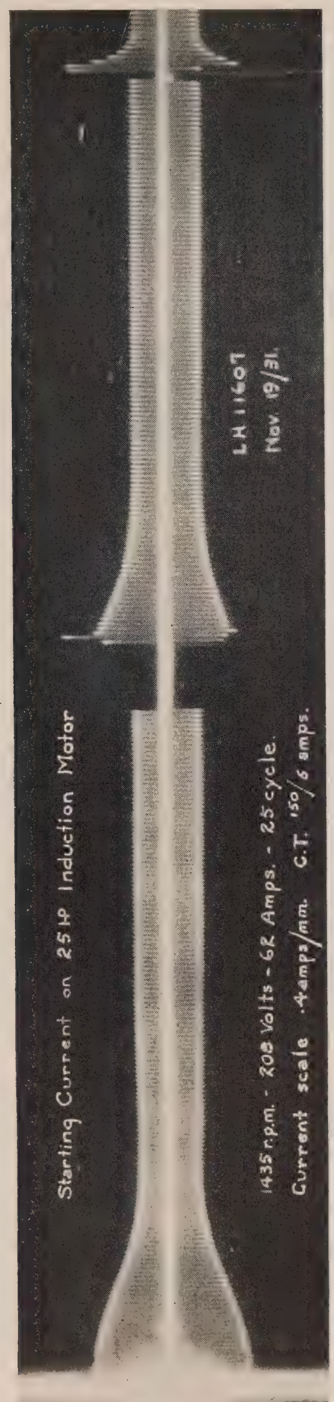


Fig. 3.

The second method within this group is that known as "Y-delta" starting. It does not have a wide application on this continent due to the method not permitting any variation of the voltage which can be applied to the motor windings. As the name implies this method of starting depends on a change being made in the electrical arrangement of the stator windings. Each end of the three-phase windings of the stator are brought out separately to a suitable switch. This switch in one position connects the windings in Y for the starting period and in another position connects the windings in delta for the running position or normal operating position of the motor. Connecting the stator windings in the Y arrangement subjects the winding to approximately 58 per cent. of full line voltage and reduces the current taken at the start proportionately. When the windings are re-arranged in the delta position each winding receives full line voltage. As the voltage ratio impressed on the motor windings is fixed definitely in the ratio of 57.8 to 100 the torque is also fixed. The torque varies as the square of the applied voltage, therefore it will be seen that by this method of starting 33 per cent. of the torque which would be developed if full voltage were applied to the motor can only be secured when the motor is connected in Y. It is obvious, therefore, that this method of starting can only be used where a motor is to be started up under light starting conditions and where this torque will accelerate the motor to a reasonable speed. The motor itself is of special design as the six leads are brought outside the

motor frame. During the throwover from Y to delta the motor is disconnected from the line and is subject to the same operating faults as outlined for the auto transformer starter.

Figure 4 is an oscillogram of the starting current of an induction motor arranged for "Y delta" starting. Four starts were made on this motor, the oscillogram records indicating the surge which takes place when the switch is thrown from the Y position to the delta position, at which time the motor is momentarily disconnected from the lines.

The starters for polyphase induction motors which do not disconnect the motor from the line after the motor has been energized are the "full voltage" method, the "primary resistance" method, the "primary reactance" method and the "secondary resistance" method used in wound rotor motors. The "full voltage" starter is the most simple starter used. It consists of a switch with overload and low voltage trip mechanism. As this starter simply connects the motor to the line it is necessary that it only be used where the full voltage starting current of the motor is within limits which will not cause objectionable disturbances. The so-called "line start" motors which are specially designed to reduce the current at start permit larger motors to be operated by this simple starting method than if standard squirrel cage induction motors only were available. The initial current surge at the moment the motor is energized is the only disturbance which this type of starter may set up. As the motor gains speed the current value rapidly dies down to

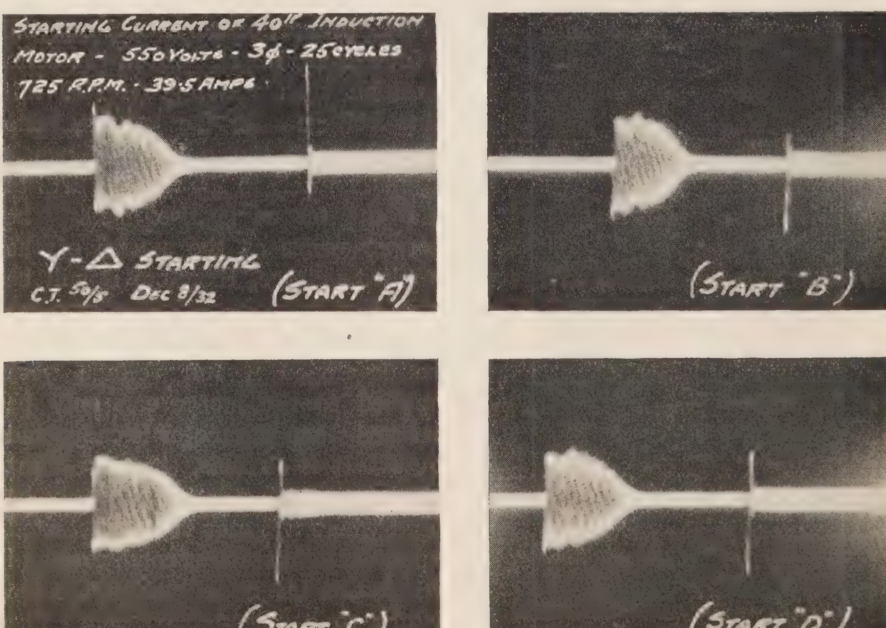


Fig. 4.

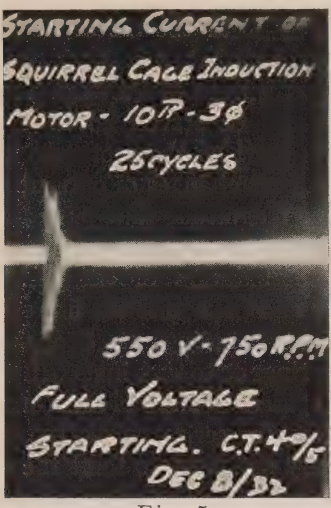


Fig. 5.

a percentage of full load current.

Figure 5 is an oscillogram of the starting current of a squirrel cage induction motor started at full voltage.

Primary resistance and primary reactance starting equipment operates on the principle of inserting in the leads to the stator windings resistors or reactances which limit the value of current taken when the motor is first energized. In the case of the resistance starter values of resistance are shunted out of the circuit by the starting mechanism until the full supply voltage is impressed on the motor winding. In some starters this is carried out in steps of definite value, that is, all the resistance may be shunted out in two or three definite steps. In other types of resistance starters the resistance is gradually changed from a high value to a low value and then finally shunted out of the circuit. The reactance method limits the current taken by the motor and when the motor has obtained its rated speed the reactance is cut out of the circuit. These types of starters are usually arranged for push button control or automatic starting of the motor in which case the operator after pressing the starting button has no further control over the starting period.

The advantages of these two methods from the electric utility viewpoint are that the starter can be so designed that definite values of current are taken from the supply lines at definite time intervals and that after the motor has been connected to the supply line it is not disconnected again and a second connection made, with the motor running. The possibilities of disturbances being set up on the supply lines are therefore greatly reduced. Values of time and current are definitely known and the personal element in the starting cycle is eliminated.

Figure 6 is an oscillogram showing the starting of a 100 horsepower self-starting synchronous motor equipped with an automatic resistance type starting panel and three steps of resistance. This synchronous motor is driving an ammonia compressor and is required to start under partial load. As indicated on the oscillogram the motor does not move until the third step of resistance has been cut out. The current taken from the line is increased in definite values from the time the starting contactor is closed until the motor begins to move. While this oscillogram shows the start of a synchronous motor it is characteristic of the start of the squirrel cage induction motor up to the point where the motor is started and is increasing in speed. Where the resistance is reduced gradually the current is obviously built up

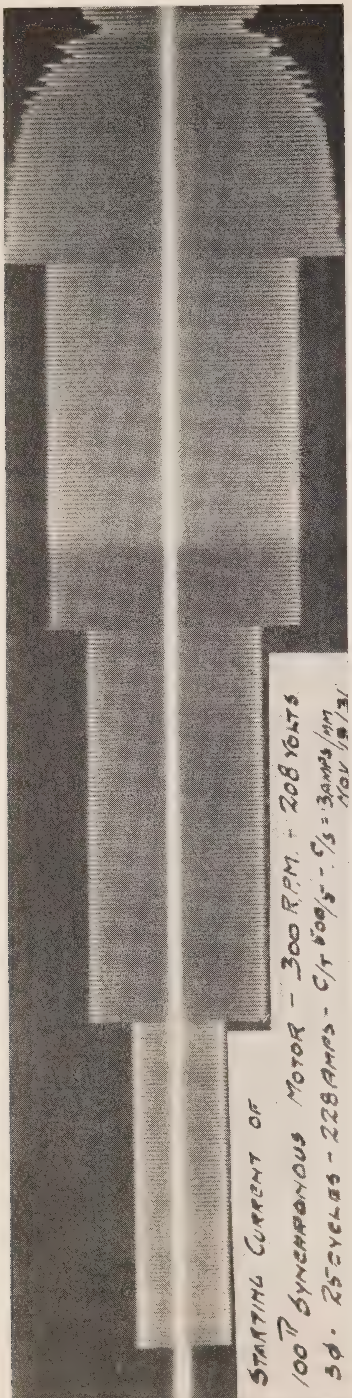


Fig. 6.

gradually until the motor begins to turn over and then reduces again to some percentage of full load current. This type of starter gives a very smooth start to the motor as no instantaneous changes of current value of large magnitude take place.

The starting of phase wound motors is a combination of the resistance starter and the across-the-line starter. The rotor windings are brought out to slip rings or to terminals within the rotor spider. Values of resistance are inserted in series with the rotor windings sufficient to limit the starting current to one and a half or two times the full load current. The resistances may be located inside the rotor spider in which case they are cut out of circuit by a centrifugal switch. When slip rings are used the resistors are mounted external to the motor and cut out of the rotor circuit by some type of drum controller or where an automatic panel is used by magnetic contactors. Where heavy starting duty is required or where low values of starting current are desired the phase wound motor is very satisfactory. A measure of speed control can also be secured by the resistance steps as with a given value of resistance a definite speed for that torque will result. While the phase wound induction motor has very desirable starting characteristics, with certain types of control much depends on the operator. Where the resistance controller is not interlocked with the line contactor it may be possible to close the line contactor and energize the motor at full line voltage without the rotor resistance being inserted. Starting in this way is equivalent to operating a squirrel cage motor with an

across-the-line starter and will cause disturbances on the supply line. Again if the motor has been started with all the secondary resistances inserted the operator may cut out the steps of the rotor resistance so rapidly that the motor has not time to accelerate properly. This will also result in line disturbances being set up. The above remarks do not apply to the phase wound induction motor with self-contained resistances as the operator has no control of the motor after the line switch has been closed. This type of motor is only used for fixed speed duty and is not adaptable to varying speed. Modern phase wound rotor starting equipment is made with automatic interlocks between the line contactor and the rotor resistance drum controller so that the starting sequence must be performed in the correct manner.

Figures 7 and 8 show the starting current of two wound rotor induction motors.

Suggestions have been made from time to time by motor manufacturers both on this continent and in Great Britain that electric utilities should formulate their motor starting conditions on some definite basis. This would be very desirable if it were possible to work out a formula that could be generally applied. The various factors which enter into the supply of electric energy to consumers using polyphase induction motors make the application of a general formula unsatisfactory from the electric utility viewpoint. In some cases transformer banks supplying consumers are located on the consumer's premises, while others are fed by services taken from transformer banks at some distance away from their plant. All else being equal larger starting currents might be allowed in the one case when compared with the other without greater voltage drop on the supply lines. Consumers having a few small motors, where the supply is from relatively small transformer banks may be, allowed to take a higher ratio of starting current to full load current

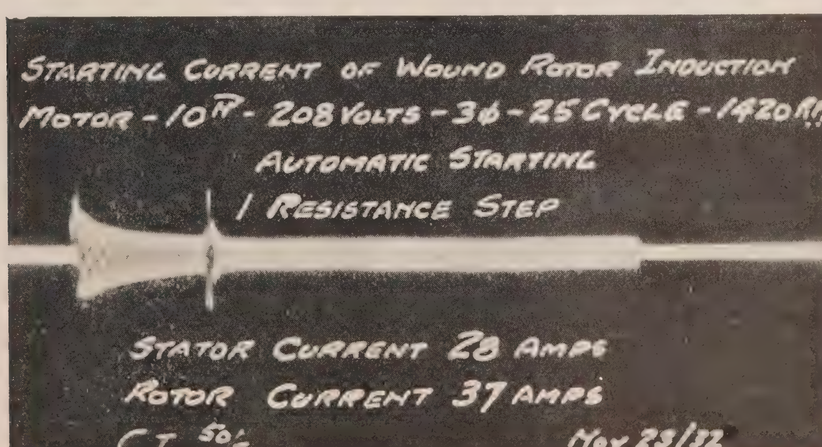


Fig. 7.

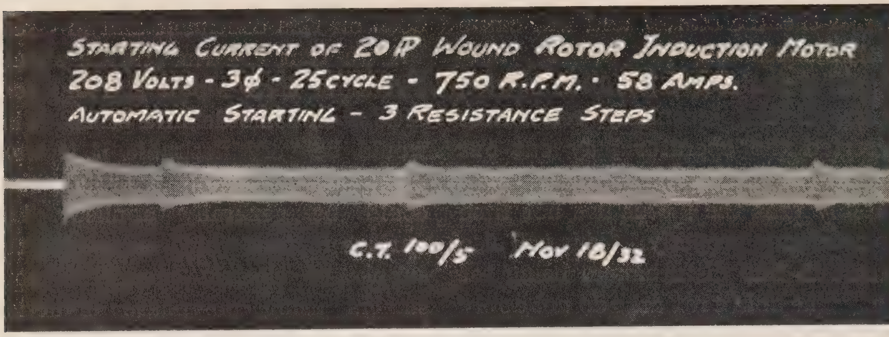


Fig. 8.

than a consumer having a large number of motors of high horsepower rating and supplied from a proportionately larger transformer bank. This is partly due to the reactance of standard power transformers increasing as the size of the transformer in kv-a. increases.

A 5 kv-a. power transformer may have as low as 2 per cent. reactance while a 200 kv-a. transformer may have 5 or 6 per cent. reactance. Obviously if the same ratio of starting current to transformer bank capacity were permitted in each case the voltage fluctuation due to the starting of the motors supplied by the large bank of transformers would be probably two and a half or three times as great as the voltage fluctuation on the smaller bank.

Another factor that has a bearing on the starting current permissible which would be difficult to evaluate in a formula is the number of starting periods per unit of time for a given motor. If a motor has to be started once every few minutes a lower starting current would be advisable than if the same size motor were only started once each day. The motor started every few minutes is much more likely to be started simultaneously with some other motor in the plant than would be the case where it only started once or twice a day. As previously stated dips in the lighting if occurring two or three times an hour tend to cause irritation in the personnel working under the lighting affected. As the conditions relative to each consumer are likely to differ in several ways the most satisfactory method to insure suitable starting equipment being applied to motor installations is for the consumer, the motor manufacturer and the electric utility to co-operate where motor installations are being considered. All the factors relative to the motor application can be evaluated, the peculiarities of the motor drive, the number of starts to be made in a given time, the capacities of lines and transformer banks and any other factors entering into the problem can be given due consideration.

Where a consumer already has a motor installation and is considering placing further motors in his plant the starting current of the largest motor which he is operating usually sets the maximum value for further motor installation. If a large phase wound motor is installed which meets the electric utility's conditions as far as

starting current is concerned smaller motors installed in the plant could be permitted to take up to approximately the same value of starting current. One factor, however, which should be considered in this case is the frequency of starts of the two motors. If the large motor is started frequently and the smaller motor also started frequently the starting current taken by the smaller motor should be reduced. Co-operation when considering motor starting equipment should not be difficult to secure if it is realized that it works to the benefit of all concerned. It tends to reduce trouble that the consumer might otherwise have in the production of his product which in many lines of manufacture is a serious factor. It tends to maintain the prestige of the motor manufacture with the consumer in that a satisfactory installation results. The electric utility also benefits by the reduction of complaints from the consumer making the installation as well as possible complaints from other consumers who may be fed from the same supply lines and equipment.

Within recent years many of the electric utilities have installed in the downtown areas of the larger cities alternating current low tension networks from which energy for power purposes is supplied as well as energy for lighting. Due to the standard design of the transformer banks supplying these networks, the use of one size of conductor in the supply mains and to the fact that the transformer banks are usually regularly spaced over the network area it has been possible to formulate fixed motor starting conditions covering motors operated from a network service. Many of the variable factors which have to be taken into consideration when determining permissible starting currents in scattered industrial plants or in industrial areas do not exist on the network. A large percentage of the load supplied by the alternating current low tension network is a lighting load and it is, therefore, necessary that disturbances which might be set up on the network by the operation of motors be kept to a minimum. Electric utilities operating alternating current low tension networks have, therefore, carefully studied this question. The Toronto Hydro-Electric System has adopted the following conditions covering the starting of polyphase induction motors from network services. It will be noted that these conditions are based on the installed capacity of the motors on the consumer's premises only.

Regulations for Motor Starting Currents

Characteristics of Service 208 Volts, Three-Phase Alternating Current, 25 Cycle

(1) In services on which the total installed capacity is 100 horsepower or less, the momentary starting current of any motor connected must not exceed 100 amperes.

(2) On services on which the total installed capacity is greater than 100 horsepower but does not exceed 400 horsepower, the momentary starting current of any motor connected must not exceed 100 amperes plus 1 ampere per horsepower of installed capacity above 100 horsepower up to a maximum of 200 amperes.

(3) On services on which the total installed capacity exceeds 400 horsepower, the momentary starting current of any motor connected must not exceed 200 amperes plus 1 ampere per horsepower of installed capacity above 400 horsepower up to a maximum of 300 amperes.

(4) If the momentary starting current of any motor exceeds the maximum permissible value as given in the above rules, it must be equipped with a starting device which will limit the starting current to increments each within the permissable value and at intervals of not less than one-half second. The starting device must not open the circuit during the starting period.

(5) Motors suitable for single phase 208 volt operation will be allowed up to a rated capacity of 5 horsepower and for 120 volts operation up to a rated capacity of 2½ horsepower.

So far the motor installations which have been installed on the alternating current network under the above outlined starting conditions have operated very satisfactorily as far as the effect on lighting is concerned. No difficulty has been experienced in securing the co-operation of the consumer's engineers, the motor manufacturers' engineers and sales representatives with the System. This is the most effective way of securing satisfactory conditions in the application of starting equipment for polyphase induction motors.

THE
BULLETIN

Published by
HYDRO-ELECTRIC POWER COMMISSION
of Ontario

620 University Ave.
Toronto

Subscription Price $2.00
Per Year

Grounds

By the Committee on "Grounding" of the Hydro-Electric Power Commission of Ontario. Presented by Wills Maclachlan, Chairman.

(Presented to Association of Municipal Electrical Utilities at Windsor, June 24, 1933.)

TO ensure the safety of persons and the efficient operation of circuits, it is necessary, at times, to ground.

The ground consists of a grounding wire, and an electrode inserted in the earth. As with all electrical circuits the resistance and the carrying capacity of the connections are of the utmost importance.

In 1927, Mr. E. M. Wood presented a paper on "Grounding" before the Association of Municipal Electrical Utilities which gave the reason for grounding and dealt with the electrode. The problems of multiple grounds and of methods to be used in the grounding of stations, transmission lines and distribution circuits were described and discussed; also the then-known methods for testing the resistance of grounds.

In 1932 Mr. A. G. Lang presented before this same body, a paper on "Ground Connections for Electrical Distribution Systems" in which the hazards of distribution and their reduction were considered. The hazards of inadequate ground connections and the installation and characteristics of ground connections were also discussed.

In 1925 The Hydro-Electric Power Commission of Ontario created a Grounding Committee whose duties are to investigate the problem of grounding and to act as a clearing house for information pertaining to grounding. As all interested departments of the Commission are represented on this committee and as meetings are held monthly, developments in any one department are made available to all others. By discussing the different problems involved, the Committee has been able to initiate various tests and studies, some of which are here presented, others being still under investigation.

Testing of Grounds

A true picture of the testing and accurate determination of earth

CONTENTS

Vol. XX **No. 8**

August, 1933

resistance can only be obtained by a careful study of the characteristics of the paths of current flow. Extensive treatises are available to assist anyone in such studies and it is beyond the range of the present paper to discuss these in detail. The important features involved, however, include the following:

Current paths are seldom parallel for any appreciable distance. This results in an equivalent cross-section of conductor which is extremely variable and impossible to estimate except in a few special cases. The direction of the return current and the distance to which it must flow depend on the type of circuit involved in such case and hence the resistance measured should be considered with respect to the service or protection expected therefrom.

The specific conductivity of the soil or other earth constituents may be quite variable and the earth may also contain cavities or interstices. Conductivity dependent on moisture tends to rise with temperature but if fault current be maintained the effective ground resistance may be found to drop at first and then rise later if moisture be driven off as steam around a concentrated electrode.

Cavities or other small gaps may, under the application of high voltages, e.g. lightning, break down and give an effective resistance less than any value measurable by low-voltage methods.

Stray currents flowing in the earth may interfere seriously with some methods of measuring earth resistance. Direct-current methods would be vitiated by the presence of direct-current return circuits, such as those of street-railway, direct-current systems. Alternating-current methods must avoid the presence of a stray current of the same frequency as that used on test. Such currents may be fed directly into the earth by grounded a.c. systems or be induced by the electromagnetic and electrostatic effect of overhead transmission lines.

In any case the testing equipment must be protected from or be capable of carrying without injury any such stray current which might pass through it while tests are being made.

Another precaution necessary when using low-voltage, direct-current methods is to avoid the effect of electrolytic e.m.fs. by using comparison electrodes of the same material as that of the electrode under test. It is possible to obtain extremely inaccurate results due to the use, for example, of a copperweld ground rod used as a reference ground to measure the resistance of a tower footing grillage of galvanized steel.

Early methods of testing ground resistances usually involved placing or otherwise obtaining two auxiliary electrodes of low resistance fifty feet or more from the electrode under test, measuring the resistance directly between each of the three pairs, then

calculating the value of the one required from the simultaneous equations relating the values of the three grounds. This "three-point method" could be used with practically any of the measuring instruments available for such work, but the labor was excessive and the results might in some cases be subject to large errors.

A quite different scheme is available in the vicinity of power stations and distribution lines. This is the nearest approximation to actual power-line conditions and consists of passing into the ground at any desired point current controlled by suitable resistors and measuring by means of voltmeters the potential drop in the vicinity of the ground under test. This scheme is valuable in that a test on the continuity of the circuit is made, the paths of current-flow are similar to those occurring under fault conditions and a diagram of potential gradients may be drawn which would indicate other possible points of hazard.

The most recent methods of measuring the resistance of grounds on distribution systems require an auxiliary ground at an approximate distance of fifty feet and current is passed through this in series with the ground under test. With rod electrodes the resistance is largely localized within a few feet of the rod. Hence a "probe" rod midway between these electrodes may be used, and a potential obtained between this and the electrode under test properly applied to the measuring instrument, gives a reading indicating directly the resistance of the ground without any excessive calculation.

Two types of instruments utilizing this principle are the "Groundometers" supplied by the S. W. Borden Company, New York and the "Megger" and "Meg" Earth-testers made by Evershed and Vignoles, England. The groundometer obtains its supply from a dry-cell and by means of a buzzer supplies an alternating current to ground for testing. The ground resistance is determined by adjusting a contact on a slide-wire to a position which gives no sound in a telephone receiver connected between this contact and the probe terminal.

The megger and meg earth-testers are supplied with small hand-driven direct-current generators giving at proper speed from 75 to 100 volts. The current passes through a synchronous reversing commutator and is fed into the ground at a frequency which depends on the speed of rotation. A similar reversing switch converts to unidirectional current the potentials picked up between probe and tested ground. A dynamometer movement serves to give proper indication of the resistance as obtained by dividing this potential by the current flowing. This instrument will operate satisfactorily even in the presence of quite high voltages from extraneous sources, as its speed can be regulated to tune out undesired frequencies. Both of these general types are independent of electrolytic potentials.

RESEARCH

(1) *Classification of Soils*

For purposes of rating comparative values of resistivity, the values obtained from about seventeen hundred driven grounds were tabulated under various terms used to designate the types of soil encountered. It was found that for practical purposes three general classifications of soil, excluding rock, would be sufficient to indicate

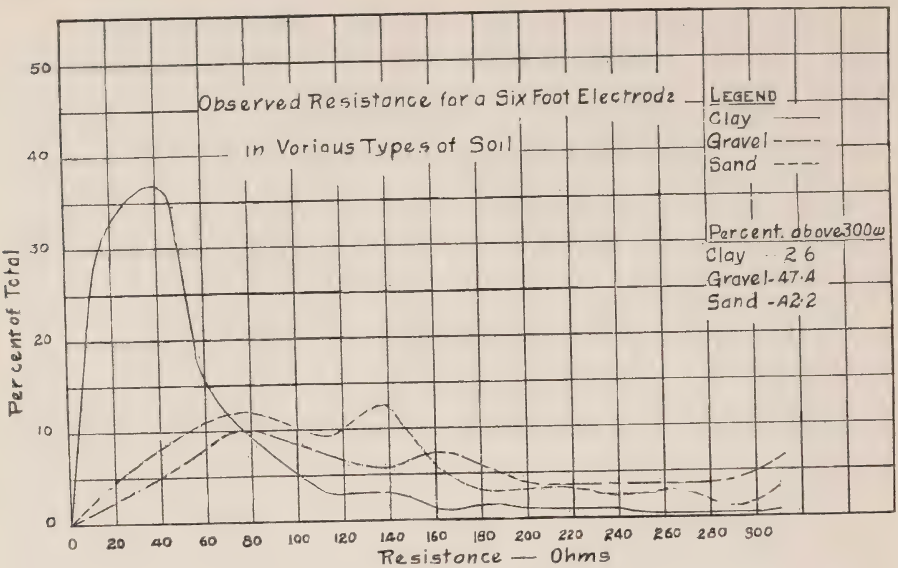


Fig. 1

the approximate resistance which might be expected from a certain type of electrode or, conversely, the difficulty which might be expected in obtaining low-resistance values.

Clay and clay loam indicated resistance between twenty-five and fifty ohms for three-quarter-inch rods driven six feet.

A mixture of clay with sand or sandy loam might vary from fifty to two hundred and fifty ohms.

Sand or gravel alone would result in a large number of values over three hundred ohms, with the same type of ground electrode.

(2) *Improvement of Electrode*

Until 1926 the H.E.P.C. standard ground electrode consisted of a six-foot length of one inch wrought-iron pipe fitted on one end with a cast-iron point and on the other with a cast-iron driving cap arranged to take the connecting-wire. This cap was so shaped in its interior that it wedged on the pipe during the driving and thus secured the connecting-wire between pipe and cap. Experience with this type of electrode over many years proved the worth of the driven electrode but also showed that a better method of connecting the grounding wire would be very desirable.

In 1926 the standard was changed to a six-foot copperweld rod five-eighths inch in diameter, using a compression-type connector for securing the grounding wire. Due to its smaller diameter this rod was much easier to drive and it was found that there was very little increase in the resistance due to the smaller contact area. As a matter of fact, a larger percentage of electrodes was driven full depth in the denser soils, and in consideration of this fact an overall gain must be credited to this thinner rod. At the time of this change of standard, representations were made

regarding the superior corrosion-resisting properties of copper for use underground.

The claim was questioned and investigations were made to find if there had been serious deterioration of the wrought-iron pipes which had been used. Pipes that had been in service twelve years were pulled out and examined. Iron rods that had been installed as lightning rods forty years ago were examined. Other operating companies were asked for their experience and the Bureau of Standards at Washington was asked for its experience on rods installed in 1915. The net result of this investigation was to the effect that iron or steel might be used with reasonable certainty and that although there might be isolated cases of corrosive soils, Ontario was particularly free from such conditions.

After investigation it was decided that the maximum permissible resistance should be set at 25 ohms. It was then clearly evident that to obtain this result some different form of electrode must be employed. Analysis of the results of early improvement work showed that the greatest single controlling feature was the moisture line. That is, the best chance of improving resistance lay in the use of a longer rod. The penetration of the electrode into permanently moist soil not only gives a much reduced resistance but also improves the "all season" characteristics of the electrode as regards fluctuation of resistance due to seasonal changes such as frost, drought, wet seasons, etc.

A striking example may be cited of the effect of long electrodes where deep sand occurred near a lake shore. Permanent moisture was encountered at fourteen feet and satisfactory results were finally obtained by using a twenty-foot electrode. These conditions were extreme but serve to illustrate the necessity of reaching moisture, as in this case any electrode less than fourteen feet long was of very little value.

In 1930, the standard electrode was changed to three-quarter-inch, steel rod ten feet long, and an improved type of connector was developed. In choosing a standard which is to be applied to any large property, such as that of the Commission, many considerations must be taken into account. In the case of this change, information was obtained which indicated that an increase in the length was almost essential; on the other hand increased difficulty in driving had to be considered.

(3) *Method of Driving Rods*

Driving tests were made which showed that with a three-quarter-inch diameter and by the use of a simple driving tool the ten-foot length of rod could be driven into every soil. This tool is shown in Fig. 2, and has the following advantages:

- The driving time is reduced.
- An elevated platform is not required.
- The rod is not bent.
- The end of the rod is not mushroomed.

To comply with standard specifications the rod must be driven so that its top is at least eight inches below the surface of the ground. It is therefore necessary to remove some earth in order to attach the clamp, and it is recommended that this earth

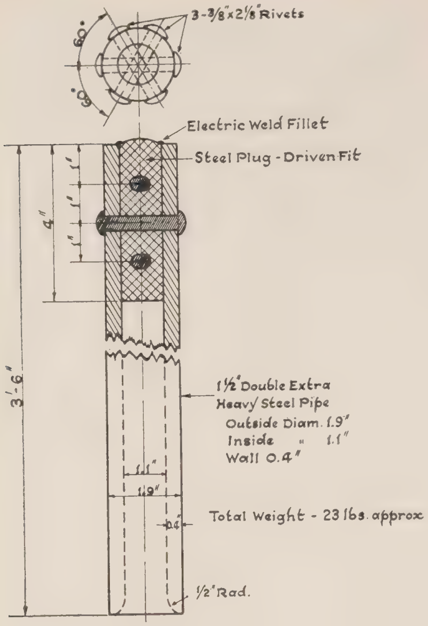


Fig. 2—Driving Tool for ¾ in. Ground Rod.

be taken out before the driving is commenced. The tool is slipped over the end of the rod which is then raised to a vertical position in the hole which has been prepared. This will bring the lower end of the tool within reach of a man of ordinary height.

When the driving has been carried as far as the tool will go there is still three feet of rod to drive. This must be done in the ordinary way with a hammer but the rod is then in a position where it can be driven by a man standing on the ground.

Deep sand occurring where permanent moisture is beyond the reach of the standard ten-foot rod, requires special attention. In such cases, it is recommended that one-half-inch galvanized water-pipe be used. This pipe can readily be obtained in lengths up to twenty feet.

A conical basin as shown in Fig. 3, should be dug, from the bottom of which a three-inch hole should be bored using an earth-boring auger. The sand taken from this hole will give evidence of moisture when encountered, and in the case of wet sand the wall of the hole will not hold and it will be impossible to bore any deeper. A length of pipe should be chosen that will give about six feet penetration below the moisture line and one end of the pipe should be swedged to a point. The ground-rod driving-tool is then slipped over the other end of the pipe and the pipe lowered into the hole. Care must be exercised to make sure that the upper end of the pipe does not come near live wires overhead. The pipe is then driven until the top is four inches below the surface of the ground. The three-inch auger hole must be backfilled and tamped, preferably with top soil and the basin then filled with salt to within six inches of the ground level.

A standard three-quarter-inch-ground-rod clamp may be used to connect the ground wire.

The charge of salt must be well saturated with water and the hole then backfilled and well mounded.

(4) *Test Stations*

In July, 1932, approval to establish test stations in the vicinity of Toronto was obtained in order that first-hand information regarding the effect of seasonal changes on the resistance of various types of electrodes in different soils might be ascertained. This information was available for other climates and indicated generally what might be expected. It was, however, thought advisable to have our own

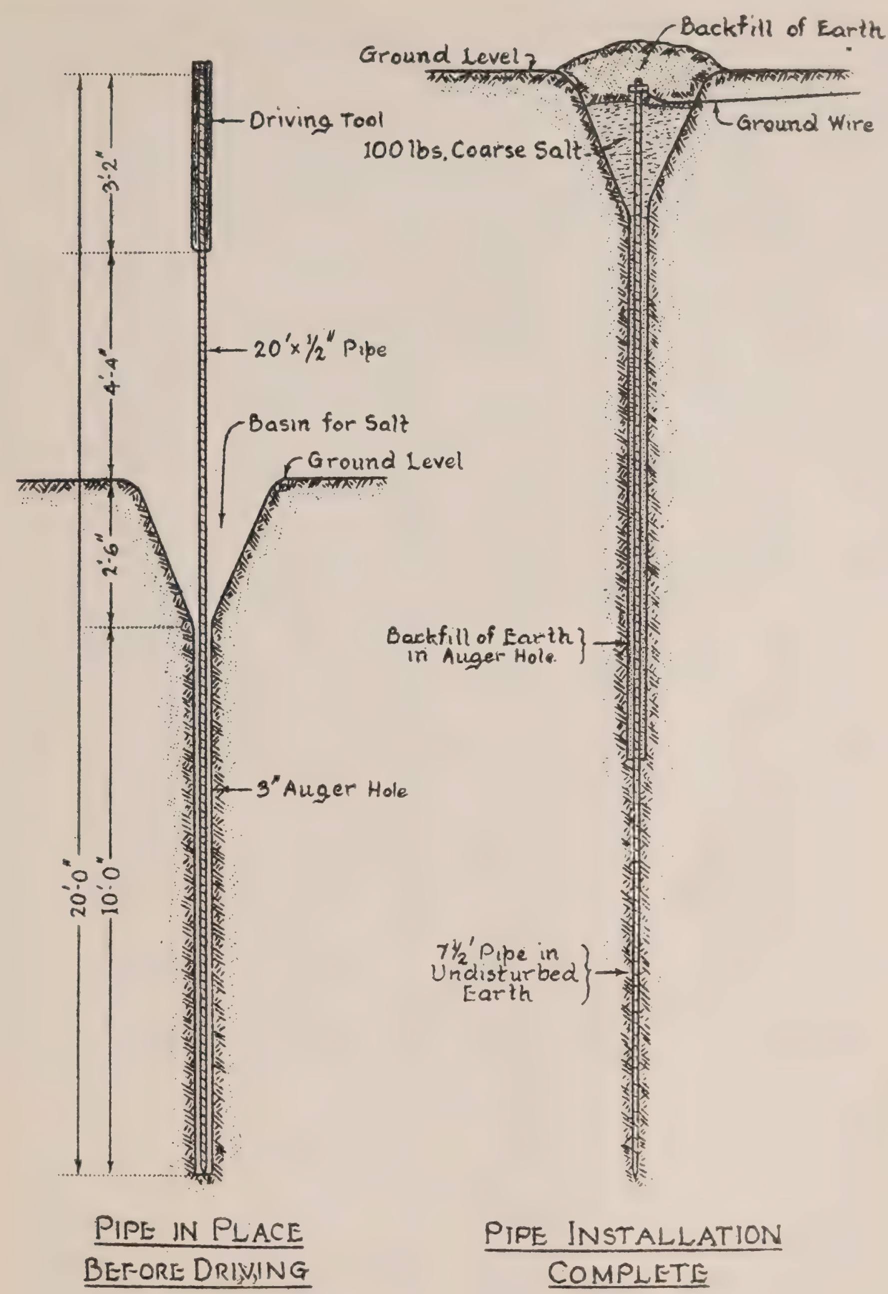


Fig. 3—Installation of driven pipe ground.

data for our own climatic conditions and soils.

A standard station layout was designed that included all types of electrodes that might prove to be practical. Electrodes were spaced ten feet apart in a straight line as it was intended to install the stations at the road side. Each station consisted of the following electrodes:—

(1) Wire mesh 20 ft. by 3 ft. buried 10 in. deep
(2) Wire mesh 10 ft. by 3 ft. buried 24 in. deep
(3) Copper strip 1 in. by 1/16 in. —15 ft. long buried 24 in. deep
(4) Copper strip 1 in. by 1/16 in. —15 ft. long buried 24 in. deep
(5) Copper strip 1 in. by 1/16 in. —15 ft. long buried 24 in. deep
(6) 6 ft. by ¾ in. steel rod
(7) 8 ft. by ¾ in. steel rod
(8) 10 ft. by ¾ in. steel rod
(9) 10 ft. by ¾ in. steel rod salt-treated (basin type)
(10) 10 ft. by ¾ in. steel rod salt-treated (tile type)
(11) 6 ft. copper tube treated with copper sulphate.

Two stations of the above layout were installed in each of four soils: gravel, sand, clay and clay or loam with rock underlying. The installation was completed on July 27, 1932, and weekly readings have been taken since that time on each electrode. The results have been tabulated and recorded graphically, together with the variations in temperature, rainfall and frost penetration.

From a study of the data obtained in these tests it is expected that we shall be in a position to recommend what form of electrode and what method of installation will yield the most effective results in the various classes of soil. As applied to Ontario this information is not now available from any other source.

METHODS OF IMPROVEMENT

(1) *In Rural Lines*

In 1929 the Commission commenced a program which covered the testing of each ground electrode on the rural lines, some twenty thousand in number. Since most of the electrodes were six-foot rods or pipes, these tests showed the resistance of a six-foot electrode at each location. The testing was carried out by the operating field-superintendent, who then made his report to the head office. Here the results were examined to determine methods and costs of improvement to some value below the allowable maximum of 25 ohms. In many cases it was necessary to visit the district to carry out experimental improvements prior to estimating the cost and preparing detailed specifications.

The following tabulation shows the extent of the work in various districts in the Niagara System and the means employed to obtain the standard resistance.

(2) *In Stations*

Standard practice for each station is to have one or more groups of 10-ft., driven rods close to the main equipment. Sky wires and distribution neutrals are connected through test links to the station grounding system. When a water system is reasonably close to the station, it also is connected to the station grounding

GROUND IMPROVEMENT IN RURAL DISTRICTS
DISTRICTS IMPROVED TO 25 OHMS AND METHODS USED

R.P.D. No..	DISTRICT NAME	Total No. of Grounds	A Originally Under 25 Ohms.	B Originally Over 25 Ohms.	Improved by Adding 1–10′ rod		Improved by Adding 2–10′ rods		Improved by Adding 3–10′ rods		Improved with 4–10′ rods or S.T.*	
					No.	% of B.	No.	% of B.	No.	% of B.	No.	% of B.
N1D2	Grantham.....	197	122	75	75	100	..	..	..	..	..	..
N1D3	Jordan........	128	65	63	54	83	7	11	..	..	2	6
N3D1	Markham.....	325	35	290	142	49	50	17	92	32	6	2
N3D2	Scarboro......	242	45	197	113	57	28	14	44	23	12	6
N3D3	Bond Lake....	533	79	454	264	58	90	20	80	18	20	4
N3D4	Newmarket....	112	9	103	50	49	42	41	11	10	..	..
N3D5	Keswick.......	180	12	168	90	54	48	29	20	12	10	5
N16D1	Woodbridge....	506	114	392	292	75	60	15	25	6	15	4
N5D2	Georgetown....	159	32	127	82	65	15	12	10	8	20	15
N13D1	Streetsville....	263	62	201	134	66	37	19	20	10	10	5
N13D2	Brampton.....	120	15	105	95	90	10	10	..	..	..	..
N5D4	Elora.........	77	27	50	25	50	8	16	7	14	10	20
N7D1	Baden........	240	40	200	100	50	40	20	35	18	25	12
N7D2	St. Jacobs.....	132	13	119	60	50	20	17	20	17	19	16
N7D3	Elmira........	40	3	37	24	65	5	13	4	11	4	11
N8D1	Tavistock.....	172	29	143	100	70	20	14	15	10	8	6
N8D4	Stratford......	85	10	75	50	67	15	20	10	13	..	..
N8D2	Goderich......	86	40	46	35	76	11	24	..	..	..	..
N8D3	Walton........	69	5	64	36	56	17	26	11	18	..	..
N8D5	Harriston......	50	5	45	25	56	10	22	5	11	5	11
N8D6	Palmerston....	72	12	60	45	75	10	17	5	8	..	..
N8D7	Mitchell.......	163	163	0	..	..	..	..	..	..	..	..
N8D8	Listowel.......	130	15	115	100	87	10	9	5	4	..	..
N8D9	Milverton.....	80	35	45	45	100	..	..	..	..	..	..
N8D10	Seaforth.......	43	43	0	..	..	..	..	..	..	..	..
N8D11	Clinton.......	204	37	167	131	79	19	11	17	10	..	..
N9D1	St. Marys.....	246	122	124	118	95	6	5	..	..	..	..
N4D1	Dorchester...	307	28	279	114	41	68	24	77	28	20	7
N4D2	London.......	640	40	600	300	50	100	17	100	17	100	17
N4D3	Delaware......	297	52	245	150	61	32	13	23	9	40	17
N4D4	Strathroy......	137	44	93	53	57	15	16	13	14	12	13
N4D5	Lucan.........	90	10	80	60	76	10	12	10	12	..	..
N4D6	Exeter........	147	28	119	75	63	25	21	19	16	..	..
N4D7	Ailsa Craig....	11	7	4	4	100	..	..	..	..	..	..
N10D1	Norwich.......	325	50	275	150	55	100	36	15	5	10	4
N10D2	Woodstock....	320	107	213	154	72	24	12	20	9	15	7
N10D3	Ingersoll......	400	20	380	130	34	100	26	80	21	70	19
N10D4	Tillsonburg....	309	53	256	171	67	25	10	25	10	35	13
N11D1	St. Thomas....	383	108	275	200	73	30	11	25	9	20	7
N11D2	Aylmer........	251	91	160	114	72	15	9	16	10	15	9
N11D3	Dutton........	91	18	73	46	63	13	17	7	10	7	10
N14D10	Bothwell......	73	33	40	23	58	10	25	7	17	..	..
N14D11	Thamesville....	127	37	90	50	56	20	22	10	11	10	11
N18D3	Oil Springs....	40	30	10	10	100	..	..	..	..	..	..

GROUND IMPROVEMENT IN RURAL DISTRICTS
DISTRICTS IMPROVED TO 25 OHMS AND METHODS USED

R.P.D. No.	DISTRICT NAME	Total No. of Grounds	A Originally Under 25 Ohms.	B Originally Over 25 Ohms.	Improved by Adding 1–10′ rod		Improved by Adding 2–10′ rods		Improved by Adding 3–10′ rods		Improved with 4–10′ rods or S.T.*	
					No.	% of B.	No.	% of B.	No.	% of B.	No.	% of B.
N18D4	Sarnia	283	108	175	100	57	15	9	20	11	40	23
N18D5	Petrolia	45	15	30	30	100	..	..	..	..	..	..
N18D6	Forest	125	25	100	55	55	10	10	5	5	30	30
N18D7	Watford	35	35	0	..	..	..	..	..	..	..	..
N18D8	Brigden	70	63	7	7	100	..	..	..	..	..	..
N18D9	Alvinston	7	7	0	..	..	..	..	..	..	..	..
N14D14	Tilbury	125	110	15	15	100	..	..	..	..	..	..
N15D1	Sandwich	410	140	270	210	78	60	22	..	..	..	..
N15D2	Belle River	113	37	76	60	79	16	21	..	..	..	..
N15D3	Amherstburg	163	48	115	90	78	25	22	..	..	..	..
N15D4	Harrow	214	60	154	119	77	35	23	..	..	..	..
N15D5	Kingsville	413	48	365	190	58	100	24	50	12	25	6
N15D7	Essex	200	65	135	105	78	30	22	..	..	..	..
N14D1	Chatham	377	177	200	190	95	10	5	..	..	..	..
N14D2	Ridgetown	243	70	173	58	34	46	26	48	28	21	12
N14D3	Blenheim	165	45	120	60	50	30	25	30	25	..	..
N14D12	Dresden	52	23	29	20	69	5	17	4	14	..	..
N14D13	Wallaceburg	182	62	120	110	92	5	4	5	4	..	..
N14D15	Merlin	180	120	60	50	83	10	17	..	..	..	..
TOTALS	63 Districts	12004	3203	8801	5558	63%	1562	18%	1045	12%	636	7%

*S.T.—Salt Treatment.

system through a test link. The grounding system is designed to obtain an area surrounding the equipment at a uniform earth potential. The larger this area, the less steep is the potential gradient that can occur in the vicinity of the station. The sky-wire and the distribution neutral generally have a comparatively low resistance and so materially improve the station ground resistance. Their connections to the station grounding system are carried in the open so that they can be easily inspected to see that they are continuous. If the station ground resistance is considered to be too high, then other or additional electrodes are provided. For example: (*a*) a connection is run further than usual if a considerably moister location can be reached, for the installation of an electrode group; (*b*) if rock is close to the surface of the earth, copper cable is laid extensively, where any excavation is required; for example, around tower footings and along fence footings; (*c*) a more costly connection than usual is made to any near-by water system.

Test links are installed to provide means for measuring the resistance of portions of the station grounding system. This minimizes the cost of improving ground resistance. Care must be taken to see that the links are not short-circuited by some parallel connection such as a steel structure, by a second connection to some equip-

ment, or by two parallel and adjacent connections in the earth.

All joints are of an approved mechanical type and these together with all other parts of the grounding system must be designed to carry the maximum current that can exist on any part during a power-system fault.

In 1919, ideas on station grounding were covered by a specification which included a number of drawings giving illustrations and details, but on nearly every installation from that time to the present, a study covering special conditions and interpretation of requirements has been required. This specification is now being revised to accord with present practice.

(3) *In Transmission Lines*

The problem of obtaining good grounds on transmission lines has somewhat different aspects depending on the type of construction adopted and the types of protection employed against lightning and other causes of system outages.

Modern protective relay systems making use of impedance-distance characteristics are dependent on the effective resistance of a group of grounds in the vicinity of any line flashover or other fault, when an overhead ground wire is used. For this purpose a uniformity of value is more desirable than particularly low values, even where these could be readily obtained.

Probably the most exacting requirement concerning ground resistance that is necessary to provide a service-secure line is that imposed by lightning. The frequency of a direct stroke of lightning is so high that each individual ground must be capable of fulfilling its own function without assistance from any other grounds that may be tied in with it. This function is to limit the voltage that could be built up across a string of insulators during the time of dissipation of a lightning stroke to earth. Considering the safety factors on over-voltage usually adopted, and the fact that at lightning frequencies a somewhat higher break-down value of insulation (giving rise to what is known as an "impulse factor"), is involved, this value would usually be five or six times the normal line voltage to ground, and frequently greater. The assumption of any definite value as a lower limit for individual ground resistance presumes the probability of a stroke exceeding such assumed value. Lightning storms apparently differ greatly in intensity, and reliable records of stroke intensities also indicate great variations, the heavier discharges occurring less frequently than those not so intense. Some arbitrary value must then be assumed as a desirable lower limit of ground resistance based on economic considerations.

Wood-pole lines carrying overhead ground wires are usually grounded by means of driven rods and the problem is then not essentially different from those arising under other conditions where driven rods are used.

Steel towers may be mounted on metal grillages buried in soil, or on concrete buttments or maybe anchored to footings dove-tailed into rock. The first method provides a ground plate already of large area. Some reduction in resistance may be obtained by adding rods but usually it will be found expensive to effect much improvement unless a section

of earth or body of water having a much greater specific conductivity be within easy reach.

Local improvement of tower grounds lies largely in the latter possibility. Such body of earth or water should be not more than three hundred feet from the tower footing, and connection thereto may be made by a buried lead equivalent to No. 6 B & S gauge copper.

Some typical cases of ground improvement gave results as follows:—

One of 1940 ohms was reduced to 200 ohms; another of 1940 ohms was reduced to 80 ohms; one of 270 ohms to 160 ohms; one of 290 ohms to 58 ohms; one of 313 ohms to 92 ohms. These figures tend to show that no definite percentage of improvement can be predicted nor should any be expected, as such improvement depends on the nature of the terrain in the immediate vicinity of the tower footing.

(4) *In Consumers' Grounds*

Grounding of secondary service neutrals and exposed non-current-carrying metal parts of electrical equipment on a consumer's premises is carried out in accordance with Section 9 (Grounding) of the Rules and Regulations which form Part I of the Canadian Electrical Code. These rules definitely state what is to be grounded and how the work is to be done. Grounding in accordance therewith is required on all alternating-current systems and on services taken therefrom, where the maximum difference of potential between the conductors to be grounded and any other point on the circuit does not exceed 150 volts to ground. Grounding of the consumer's service and equipment is an essential part of the interior wiring installation and is done by the electrical contractor who installs the interior wiring systems.

The grounded conductor of the consumer's service has but one grounding connection within the building served. This connection is made by means of a grounding conductor (which must not be smaller than No. 8 B & S Gauge) connected at one end either to the neutral, or identified (white) conductor of the service, on the supply side of the service switch and cutouts, or to a terminal provided for this purpose in the service box, and at the other end to the ground electrode or electrodes.

In the rural districts the same general procedure is followed, with the exception that as consumers' services are not always located in buildings it is sometimes necessary to resort to the use of artificial grounds of which there must be at least two.

Driven rods or pipes of ¾ in. diameter are most commonly used as grounding electrodes as they have proven more satisfactory than connection to metallic well-casings or water-piping systems used for private supply.

CONCLUSIONS

(1) Papers previously presented are summarized and the functions of the Grounding Committee stated.

(2) The theory and practice of methods for the testing of grounds are presented.

(3) Studies of the resistance of electrodes in various soils, and the development of the ten-foot standard electrode are outlined.

(4) The method developed for

driving the ten-foot standard electrode is described.

(5) A description of test stations for electrodes at present undergoing a year's test is given.

(6) The method of improvement of the resistance of grounds, for stations, transmission and distribution lines and for installations on consumers' premises is discussed and the results obtained in some cases have been presented.

(7) If a circuit or a piece of apparatus is to be grounded the electrical characteristics of the connection should be known.

* * * *

The Members of the Grounding Committee are—Messrs. Wills Maclachlan, Chairman; A. S. L. Barnes, Secretary; W. L. Amos, W. G. Baxter, W. B. Buchanan, W. P. Dobson, A. G. Hall, E. F. Hinch, A. G. Lang, E. R. Lawler, M. P. Osburn and J. D. Pace of The Hydro-Electric Power Commission of Ontario, and C. E. Schwenger, (G. L. Lillie, alternate), of the Toronto Hydro-Electric System.

Record of a Job Well Done

During the morning of Saturday, February 4, 1933, Eric Holmes, a young boy living in Etobicoke Township, was skating on the marsh alongside the western shore of the Humber River. He ventured out on the river section, and broke through.

Archie K. Crawford, a lineman employed in the Operating Department, Niagara System Maintenance Line Gang, was trimming trees in the vicinity. Hearing the boy break through, he ran to his assistance. He was still wearing his lineman's equipment. He picked up a stick about five feet long and shoved it out to young Holmes. When the boy grabbed the stick, the ice gave way below Archie. They were both in deep water and forty feet from the shore. One spur caught in his pole belt. He unbuckled his belt and let his equipment and tools sink to the bottom of the river.

Meanwhile, acting on his instructions, the boy clung to the edge of the ice. Archie then took the boy's arm and broke the ice ahead of him, and made for the shore. He was almost exhausted when his feet touched the bottom. The ice was now too thick to break. Another boy skating along the shore, and carrying a hockey stick, came to the assistance of both. He pushed the stick to Holmes, and Archie, grasping the boy's feet, boosted him up onto the ice, and then crawled out himself.

On July 19, 1933, at the London High Tension Station, Mr. Wills Maclachlan, representing the Commission, presented Archie with a parchment certificate, which the Royal Canadian Humane Association had awarded him. The presentation was made in the presence of the Operating Staff of the Station, the Line Maintenance gang under Foreman Russell, the London Rural Power District gang, the London Rural Power District Superintendent Mr. R. Hughes, and Mr. G. Terry, the Line Maintenance Superintendent from Hamilton.

Prefers Electric Furnace for Gray Cast Iron

Contrary to the usual opinion, production of gray cast iron in the electric furnace may be more economical

in over-all cost than the cupola process. So said Clyde L. Frear, metallurgist of the DeLaval Separator Company, recently when addressing the American Foundrymen's Association. Among the reasons given for preference of the electrical process were:

1. Much cheaper grades of raw materials may be used without detracting from the quality of the castings. Many raw materials may be used in the electrical furnace that it would be impossible to use in the cupola.

2. Flexibility of the process. The bath of molten metal may be held as long as desired in the furnace and at the same time may be heated to any desired temperature, thus using all the advantages which may result from this high temperature refining and its control. In addition the composition of the bath and the physical properties of the resultant castings may be changed as desired at any time during the melting or refining process, so that castings of any desired composition or properties may be obtained at will during the process.

If a ladle of iron should cool too far, as is often the case when pouring a large number of small castings, it is not necessary to pig this cool metal. It is only necessary to return it to the furnace and reheat to the desired temperature.

3. Smaller heats may be made economically in the electric furnace than could be made in the cupola, which is advantageous in periods of low production.

4. Ease of superheating the metal and consequent high refining and solution of the graphite make ladle additions of alloys more effective than with a metal that is only partially refined.—*Electrical World.*

Toronto Officers of A.I.E.E.

Officers of the American Institute of Electrical Engineers for the administrative year beginning August 1, 1933, announced at its June Convention, include two from Toronto, the others being from thirteen states of the United States. A. H. Hull, Electrical Engineering Department, Hydro-Electric Power Commission of Ontario, was elected Vice-President, while A. B. Cooper, Ferranti Electric Limited, was one of the hold-over officers constituting the Board of Directors.

Wood Poles—Loading and Strength

By S. K. Cheney, Distribution Section, Electrical Engineering Dept., H.E.P.C. of Ont.

(Presented to Association of Municipal Electrical Utilities at Windsor, June 22, 1933).

In the construction of many electrical distribution systems, the selection of wood poles for power lines is based on adherence to common practice rather than on a detailed study of the load to be imposed on the poles and the strength of the poles to withstand this load.

The selection of poles by personal experience, rather than by an engineering study, results usually in poles of greater strength than the requirements for the loading. The cost of this surplus strength is probably not an economical expenditure.

In the replacement of poles which are suspected of having reached the end of their useful life, it is quite common practice to test a pole with a hammer or bar and very often poles are condemned without proper consideration of the strength necessary to carry the load on the pole. In this paper a method is discussed which may be used to determine the depreciation that should be allowed in a pole before replacement is necessary.

Pole Loading

There are three types of loading to which a pole is subjected (a) Vertical, due to the weight of the wires and other equipment supported by the pole; (b) Transverse, due to the wind pressure on the conductors and pole and (c) Longitudinal, due to unequal strain in the direction of the line.

The subject of strength of poles in lines can hardly be discussed without a consideration of the matter of guys but, for the sake of brevity, this subject is not considered in this paper.

The amount of loading in each type varies greatly according to the severity of sleet storms in any particular district. The stresses in the pole set up by the above loads on the conductor alone are small when compared to the same stresses when the conductors are covered with a coating of ice. It is quite common practice to classify loadings, arbitrarily as follows:—

(a) Light—When there is a wind of 70 miles per hour with no ice on the conductors.

(b) Medium—When there is a wind of 55 miles per hour with ¼ in. of ice on the conductors.

(c) Heavy—When there is a wind of 55 miles per hour with ½ in. of ice on the conductors.

A wind velocity of 55 miles per hour is approximately equivalent to a pressure of 8 pds. per square foot of projected area; 70 miles per hour to 12 pds. per square foot.

Usually this Province is considered as being in the heavy loading district, although some sections of the Province are not subject to severe sleet storms. A record has been kept of

the location of sleet storms in Ontario during the past ten years which have been severe enough to cause damage to power lines. The attached map of the Province shows the areas in which these have occurred. The double hatched portion indicates the area where there have been three or more storms. In some of these storms, ice has formed on the conductors to a depth of considerably more than half an inch.

A pole in service acts as a column supporting the weight of the wires and equipment and as a cantilever beam reacting against the tendency to bend set up by the transverse and longitudinal loads. Each of the three types of loading is discussed separately below.

Vertical Loading

Vertical loading sets up a compressive stress in the pole which is proportional to the weight of the load. If the pole were very slender, there would be a tendency to buckle, but poles, which meet other necessary requirements, have, for all but very extreme cases, the necessary strength to withstand buckling.

The following example is worked out to show that the vertical loading with normal equipment is inconsiderable. Assume that a 35 ft., 7 in. top, Eastern Cedar pole carries 8 No. 00 weatherproof copper wires at 125 ft. span and two 25 cycle 2,200/220 volt 25 kv-a. transformers.

The weight of one ft. of No. 00 weatherproof copper wire plus ½ in. of ice is 1.115 lb.

Total weight of 8 wires at 125 ft. span—8 $\times$ 125 $\times$ 1.115 = 1115 lb

Weight of two 25 kv-a., 25 cycle, 2,200/220 volt transformers with is say, 2,400 lb.

Total weight on pole = 1115 + 2,400 = 3515 lb.

Average ground line circumference of 35 ft., 7 in. pole = 40 in.

Area of pole at ground line = 127 square inches.

Then the compressive stress per square inch of pole would be $\frac{3515}{127}$ = 28 pds. approximately.

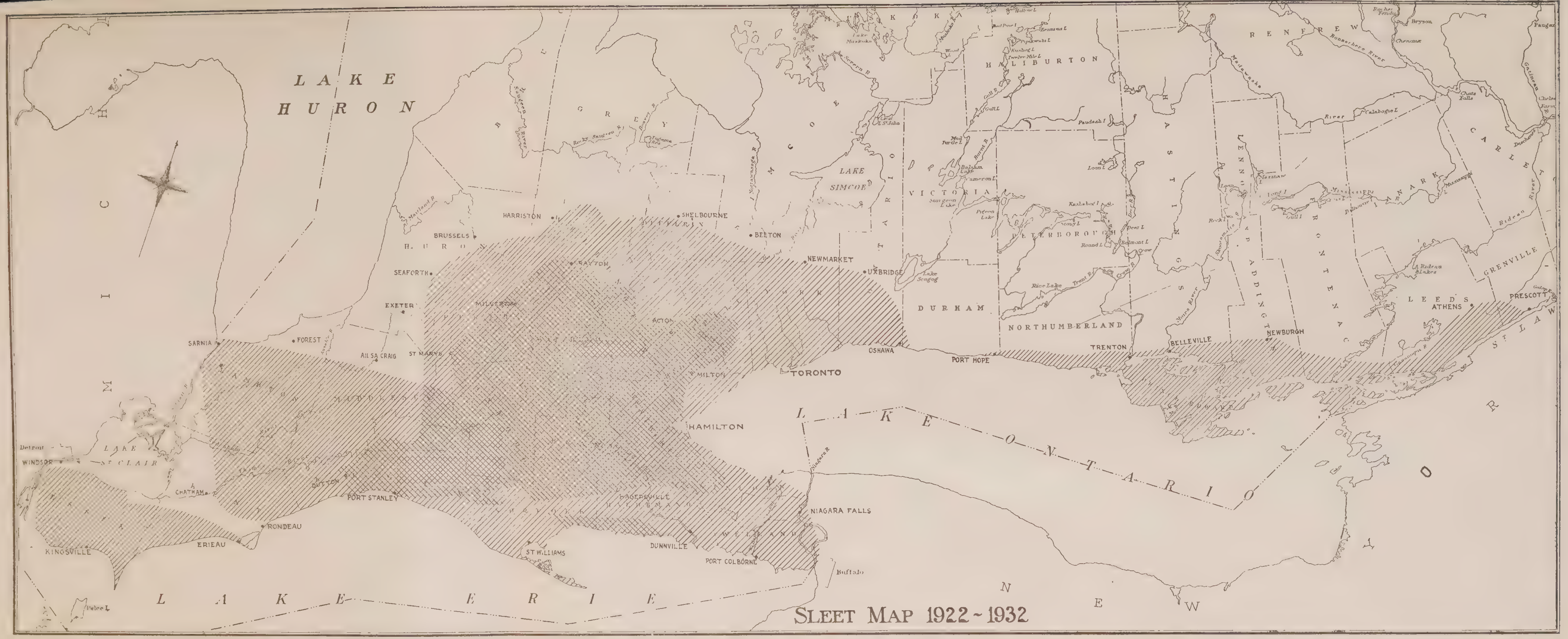
As the compressive strength of Eastern Cedar is approximately 3600 pds. per square inch, the vertical loading in this example is only 0.8 per cent. of full strength of pole.

In addition to the above vertical load, at every guyed pole there is a vertical component of the stress in the guy cable which produces a vertical load on the pole. At angles on heavy lines this may produce a buckling of the pole and it is therefore advisable to use stout poles in these locations.

Transverse Loading

The transverse load on a pole is due to the pressure of the wind tending to move the top of the pole away from the vertical position. Since the pole is assumed to be held rigid at the ground line, this sets up in the fibres of the wood a tension on one side of the pole and a compression on the other side. The force tending to produce this bending of the pole is known as bending moment and is expressed in foot pounds. It is equal to the product of the force in pounds tending to produce motion and the distance in feet of the point of application of this force above ground.

There are two forces which tend



SLEET MAP 1922 ~ 1932

to set up a bending moment, (a) Wind pressure on pole, (b) Wind pressure on conductors.

Wind Pressure on Pole—

The wind pressure on a pole sets up a bending moment at the ground line which varies with the projected area and height of the pole.

The bending moment set up by the wind on a pole may be determined from the following formula:—

$$M_p = \frac{FH^2 (d_1 + 2d_2)}{72} \text{ ft. pds.} \quad (1)$$

where M_p = bending moment on pole at ground line due to wind pressure.
F = wind pressure in pds. per square foot of projected area.
H = height of pole in feet above ground line.
d_1 = diameter of pole at ground line in inches.
d_2 = diameter at top of pole in inches.

The increased diameter of the pole due to ice may be considered if extreme accuracy is required.

Wind Pressure on Conductors—

While the pressure on the wires caused by wind within the limit of velocities to which Ontario is subject may be appreciable, the effect is substantially increased when the wires are covered with ice. Under heavy loading the diameter of the smallest wire with ½ in. of ice will be greater than 1 inch. The bending moment per wire is equal to the product of the wind pressure per foot of wire, the length of span and the height of the wire above ground.

The pressure in pounds per foot of wire may be found from the following formula:—

For wire alone $F_0 = \dfrac{Fd}{12}$ (2)

For wire and ice $F_0 = \dfrac{F(d+2t)}{12}$ (3)

where F_0 = force in pds. per foot of wire.
F = wind pressure in pds. per square foot.
d = diameter of wirê in inches.
t = radial thickness of ice in inches.

For example, take a No. 6 bare copper wire in a heavy loading district, that is, ½ in. of ice and 8 lb. per square ft. of wind pressure.

Diameter of No. 6 wire = 0.162 inches.

Wind pressure on wire alone = $\dfrac{8 \times 0.162}{12}$ = 0.108 pds. per foot.

Wind pressure on wire and ice = $\dfrac{8(0.162 + 2 \times 0.5)}{12}$ = 0.775 pds. per ft.

It is interesting to note the effect of larger wires as compared to smaller, for example, No. 0000 bare stranded copper.

Diameter of No. 0000 = 0.528 inches.

Wind pressure on wire alone = $\dfrac{8 \times 0.528}{12}$ = 0.352 pds. per ft.

Wind pressure on wire and ice = 8 (0.528 + 2 × 0.5) = 1.019 pds. per ft.

Comparing the two sizes, No. 6 and No. 0000 the wind pressure on the 0000 wire alone is 3.2 times that of the No. 6 while for wire and ice the pressure is only 1.3 times as great. The above illustrates the importance of pre-determining the amount of ice

loading to be assumed in calculations on pole strengths.

In calculations, the length of span is taken as the average of two spans, one on either side of the pole. If there are conductors on the pole at different heights above ground, allowance must be made for this difference in elevation.

The total transverse load then is the sum of the wind pressure on the pole and on the conductors.

In addition to the wind pressure on poles and conductors there is pressure produced by the wind on other equipment such as transformers, meter boxes, etc. The effect of this may be calculated by taking the projected area and multiplying by the wind pressure per square foot.

Longitudinal Loading

Longitudinal loading on a pole is due to unequal strain on the pole in the direction of the line. In stringing wires, they are pulled up to the required tension before being tied to the insulator. If the span on each side of the pole is of the same length, then the tensions on either side of the pole should balance one another even under sleet conditions. If one span is longer than the other, there will be an unbalanced tension on the pole under sleet conditions. In case of one or more broken wires in the span adjacent to the pole there will be a tension on the pole towads the unbroken span.

There are, however, two conditions which tend to limit the magnitude of this unbalanced longitudinal tension.

(a) In the case of unequal spans, a very slight bending of the pole will be sufficient to lengthen the wire in the longer span and shorten the wire in the shorter span a sufficient amount to establish a balance in tension.

(b) The common insulator tie will not prevent a wire from slipping when subjected to the strain of a broken wire and a very small amount of slip will reduce the tension in the wire.

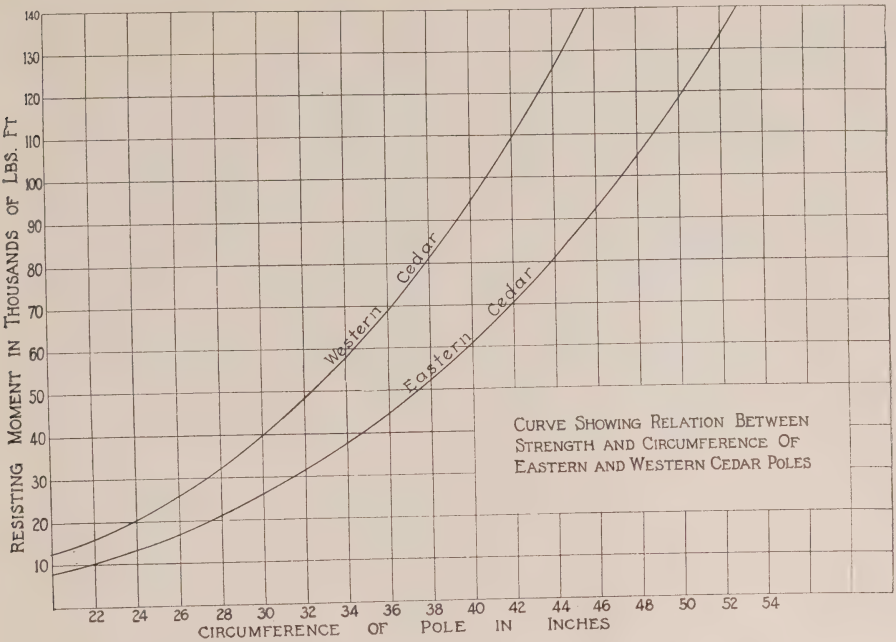
For general line construction, it is not considered necessary nor is it economically feasible to select poles for a line which will not fail when all conductors on one side of the pole are broken at once or when the pole is subjected to the strain due to deadends or angles. It is usual to provide extra strength by the use of guys.

For example, a circuit consisting of 4—No. 4 bare copper wire is carried on 30 ft. poles at 150 ft. span. If the tension in each wire under maximum loading conditions is 900 lbs., then the total load at the top of the pole, in case of failure of all four wires, would be $4 \times 900 = 3600$ pds. This would set up a bending moment at the ground line of $24 \times 3600 = 86,400$ ft. pds.

In order to withstand this, an Eastern Cedar pole having a circumference at the ground line of 45 inches would be required. This, of course, is much larger than the average pole. At angles and deadends it is necessary to provide guys to hold the unbalanced strain and the pole may be considered simply as a strut to support the wires.

Strength of Poles

Wood poles do not have the same uniformity of strength as steel columns, so that it is necessary to use, as a basis for calculation, the average strength of the various woods as



determined by experience and tests. The average strength of the individual pole is a reasonable basis for the strength of a line.

It is a common practice to use a maximum allowable fibre stress in Eastern Cedar of 3600 pds. per square inch and in Western Cedar of 5600 pds. per square inch.

The strength that a pole exerts in opposition to bending moment is known as resisting moment and is expressed in pound feet.

The resisting moment which any column will set up depends on the shape of the cross-section of the column and the strength of the material. For a column having a circular cross section similar to that of a pole the resisting moment set up is equal to $0.0002638\ fc^3$ pound feet.

Where f = allowable fibre stress in pounds per square inch.

c = circumference of pole in inches at point where strength is to be determined.

It can be proven that the weakest point in an evenly tapered pole is that point where the diameter is 1½ times the diameter at the point of application of the horizontal load. In an average 30 ft. pole this occurs from 7 to 10 ft. above the ground. However, the difference in strength between this point and the ground line is not very great, if the difference in height of the two points is considered, so it is customary to consider the strength at the ground line only, as this is the point at which pole decay and consequential weakening takes place.

From the formula given for the resisting moment of poles it can be seen why the strength of a large pole is so great in comparison to that of a

small pole. For example the resisting moment of an Eastern Cedar pole with a ground line circumference of 30 in. is 25,600 pd. foot, while that of a pole with 40 in. circumference is 60,800 pd. foot. Increasing the circumference by 33⅓ per cent. increases the strength 140 per cent.

Included in this paper are curves showing the relation between the resisting moment of Eastern and Western Cedar poles and the circumference. The slope of these curves indicates the rapid increase in strength with an increase in circumference.

FACTORS OF SAFETY FOR POLES

The following table is given to show the variation in the requirement of different authorities on the subject of factors of safety to use for various conditions. The figures given are those specified by the following: Board of Railway Commissioners for Canada, National Electric Safety Code of U.S.A., proposed rules of the Canadian Electrical Standards Association and the proposed specifica-

FACTORS OF SAFETY

			Dominion Rlwy. Board		N.E.S.C.		C.E.S.A.		Bell Tel. Co.	
			New	Rep.	New	Rep.	New	Rep.	New	Rep.
Power lines at crossings over railways.	Above	8000V	5		3	2	4		. .	. .
	Below	8000V	5		3	2	4		. .	. .
Power lines at crossings over communication lines of more than 2 circuits	Above 8000V	urban	5	not stated	3	2	3	not stated	3	2
		rural	5		3	2	3		3	2
	Below 8000V	urban	5		2	1.33	3		2	1.33
		rural	5		2	1.33	3		2	1.33
Power line.	Above 8000V	urban	. .		2	1	3		. .	. .
		rural	. .		N	N	2		. .	. .
	Below 8000V	urban	. .		1.33	.66	3		. .	. .
		rural	. .		N	N	2		. .	. .
Joint Power and Communication Lines.	Above 8000V	urban	. .		3	1.66	. .		a	a
		rural	. .		3	1.66	. .		3	1.66
	Below 8000V	urban	. .		2	1	. .		a	a
		rural	. .		2	1	. .		2	1

NOTES:—N—No factor of safety required.

a —In urban areas the circumference of the pole may be reduced by 3 in. both new and at replacement from that required for rural areas.

Rep.—Replacement.

tions for crossings and joint use of poles with Bell Telephone Company.

From the above it can be seen that there is a wide divergence of opinion in the matter of factors of safety to use in the design of pole lines. Poles in lines below 8,000 volts constructed by the Hydro-Electric Power Commission of Ontario in rural areas are built in general with at least a factor of safety of 2 when new and replaced when the poles depreciate to a factor of safety of 1.

SAMPLE CALCULATIONS

The following examples of the principles previously described are worked out to illustrate the method of using the formulae given:

1. What is the factor of safety in the poles of a line carrying 4 No. 4 bare copper wires on cross-arm 9 in. from the top of 30 ft., 7 in. top East-Cedar poles at span of 150 ft., in heavy loading district?

The average ground line circumference of 30 ft., 7 in. top Eastern Cedar poles is say 39 in. or a diameter of 12.5 in.

From formula (1) the bending moment on the pole would be

$$\frac{8 \times 24.5 \times 24.5\ (12.5 + 2 \times 7)}{72}$$

= 1,766 ft. pds.

The diameter of No. 4 bare copper = 0.204 in.

From formula (3) the wind pressure per foot of wire would be

$$\frac{8\ (0.204 + 2 \times 0.5)}{12} = 0.802 \text{ pds.}$$

Height of wire above ground = 24 ft. (see Fig. 1).

Span = 150 feet.

Therefore total bending moment on pole due to 4 wires would be 4 × 24

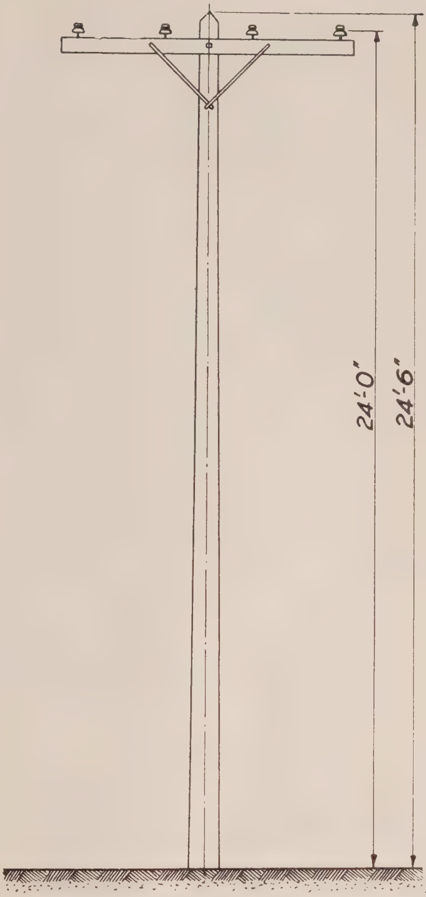


FIG. 1

× 0.802 × 150 = 11,548 ft. pds.

Total bending moment on pole = wire load plus wind pressure on pole = 11,548 + 1776 = 13,324 ft. pds.

Resisting moment of 30 ft., 7 in. top poles having a butt circumference of 39 in. would be from formula (4) $0.0002638 \times 3600 \times 39^3 = 56350$ ft. pd.

Therefore factor of safety would be

$$\frac{56350}{13324} = 4.2$$

2. It is desired to construct a line carrying 3 No. 4 weatherproof copper primary wires on crossarm. 4

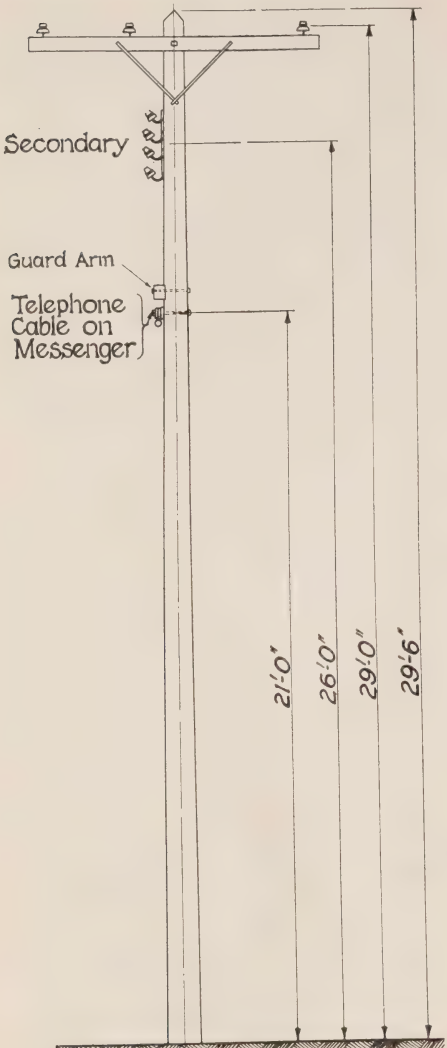


FIG. 2

No. 4 weatherproof copper secondary wires on brackets and 1–100 pair cable carried on 5/16 in. messenger on 35 ft., 7 in. top Eastern Cedar poles. Calculate maximum span for factor of safety of 2.

Average circumference at ground line of 35 ft., 7 in. top pole = 40 in. or 12.75 in diameter.

Bending moment due to windage on pole =

$$\frac{8 \times 29.5 \times 29.5\ (12.75 + 2 \times 7)}{72}$$

= 2587 ft. pds. (formula 1).

Diameter of No. 4 weatherproof copper = 0.359 in.

Load per foot of No. 4 weatherproof wire $= \frac{8\ (0.359 + 2 \times 0.5)}{12} = 0.906$ pds.

Height above ground = 29 ft. for primary, 26 ft. for secondary and 21 ft. for cable. (see fig. 2).

Therefore bending moment per foot of span for 3 primary wires = 3 × 0.906 × 29 ft. = 78.8 ft. pds.

Bending moment per foot of span for 4 secondary wires = 4 × 0.906 × 26 ft. = 94.2 ft. pds.

Total bending moment per foot of span for power wires = 78.8 + 94.2 = 173 ft. pds.

In considering cable and messenger load, it may be assumed that the space in between the cable and messenger will become a solid sheet of ice and to consider the distance from the top of the messenger to the bottom of the cable, plus ½ in. of ice on messenger and cable, as the bearing surface for the wind pressure. Assume a distance of 2.5 in. from top of messenger to bottom of cable. This then would be equivalent in projected area to a wire of 2.5 in. diameter. The pressure per foot of cable would be

$$\frac{8 \times (2.5 + 2 \times 0.5)}{12} = 2.333 \text{ pds.}$$

Then bending moment per foot of span at ground line due to cable and messenger would be 2.333 × 21 ft. = 49 ft. pds.

Total bending moment due to wire

and cable load = 173 + 49 = 222 ft. pds.

The allowable resisting moment of an Eastern Cedar pole of 40 in. circumference is equal to $0.0002368 \times 3600 \times 40^3 = 60800$ pd. ft.

For a factor of safety of 2, the total bending moment on the pole must be equal to one-half the resisting moment. The total bending moment is made up of wind pressure on poles and on conductors. The bending moment due to wind pressure on poles has been determined, viz., 2587 ft. pounds. Therefore, of the 60,800 pd. ft. resisting moment in the pole $2 \times 2{,}587 = 5174$ pd. ft. are required to provide a factor of safety of 2 for wind pressure on pole. The remainder $60800 - 5174 = 55626$ pd. ft. may be used to withstand the bending moment on the conductors.

Then the total bending moment must be equal to

$$\frac{55626}{2} = 27813 \text{ ft. pds.}$$

for a factor of safety of 2.

The total bending moment per ft. of span for conductors = 222 ft. pds. Therefore allowable span =

$$\frac{27813}{222} = 125 \text{ ft.}$$

3. Take the same poles and power load as in example 2 and replace the cable with 30 No. 104 telephone wires on 10 pin crossarms and calculate allowable span for factor of safety of 2. (figure 3).

The wire load per foot of span for the power wires would be the same or 173 ft. pds. The wind pressure on the pole would be the same —2587 ft. pds. Diameter of No. 104 wire = 0.104 in.

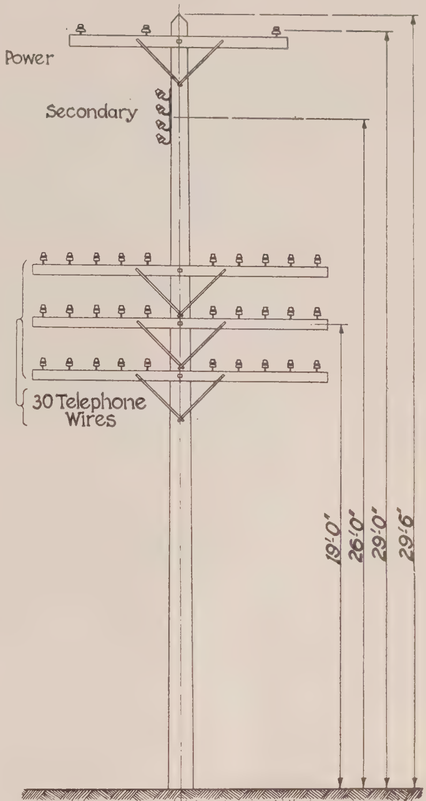


FIG. 3

It has been found by experiment that there is a shielding effect of one wire on another when there is a large number of wires on the same crossarm with close horizontal spacing. This applies to open wire telephone circuits with 10 wires on a crossarm. For purposes of calculation, this shielding allows a reduction in the number of telephone wires on a pole to 2/3 of the actual number providing the net number is not less than 10. In this example, the number, of effective telephone wires = $2/3 \times 30 = 20$.

The load per foot of span for No. 104 telephone wire would be

$$\frac{8 \times 0.104 + 2 \times 0.5)}{12} = 0.736 \text{ pds.}$$

from formula (3).

Therefore the bending moment per ft. of span for 20 wires would be 20×19 ft. $\times 0.736 = 280$ ft. pds.

Therefore total bending moment on pole due to wire load $= 173 + 280 = 453$ ft. pds.

From example 2, the allowable resisting moment of 35 ft., 7 in. top pole less wind pressure on pole and for factor of safety of 2 is 27813 pd. ft. Therefore allowable span for factor of safety of 2 with above load is

$$\frac{27{,}813}{453} = 61 \text{ ft.}$$

The above two examples show the immense advantage, from the viewpoint of loading, which is obtained by the use of cable for telephone conductors where a large number of circuits is required.

Strength of Old Poles

The following data is given as a guide in determining the time at which a pole should be replaced. The data given is based on the assumption that the remaining area of wood is sound and free from defects such as wood pecker holes, knot holes, etc. From data secured from the Department of the Interior at Ottawa, there does not appear to be any depreciation in the strength of wood through age, so that the same unit fibre stress is used as for new poles. There is a feeling among some engineers that, in towns where there is some shielding from the wind due to buildings, the factors of safety at replacement should be somewhat reduced. In our opinion, this is questionable for two reasons (1) the hazard to life due to failure is greater in towns and (2) the ice loadings in the areas outlined on the attached sleet map has been known to exceed the ½ in. which is assumed under heavy loading.

The depreciation in wood poles occurs in two ways (1) External decay and (2) Internal decay.

External Decay

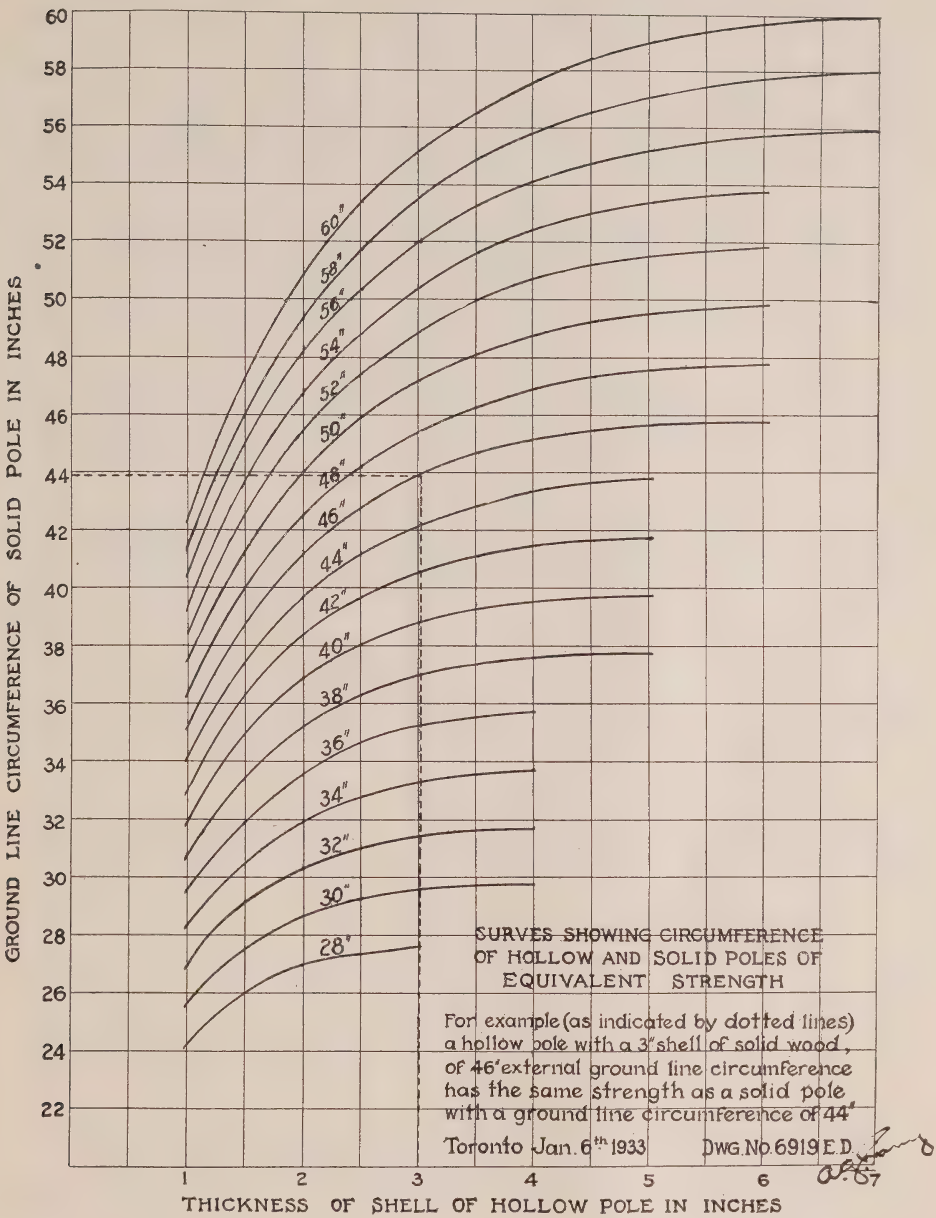
External decay usually occurs just below the ground line where the pole is subjected to an alternative wet and dry condition. The rate of decay depends on the nature of the soil, treatment of butt, etc. As has been shown before, the strength of a pole varies as the cube of the circumference, therefore any depreciation due to external decay has a considerable effect on the strength of the pole. The calculation to determine the factor of safety of a pole which has been weakened by external decay, would be carried out in a similar manner to the examples worked out above. In the accompanying tables, the circumference of poles for various factors of safety, number of conductors and heights of poles, have been tabulated for Eastern Cedar poles.

An example of the use of these tables would be as follows:

A line has been in service for some time and an inspection of a pole on this line gives the following:

Butt circumference—33 in. of sound wood with no hollow centre.
Height—30 ft.
Span—120 ft.
Load—7-No. 2 weatherproof copper wires.

From the tables it can be seen that a circumference of 33 in. at 120 ft. span on a 30 ft. pole with 7 wires gives



a factor of safety of 1.33 and pole is still sufficiently strong to carry the load. The tables are made up for No. 0 bare copper or aluminum. The error introduced through using these tables on sizes from No. 6 bare to No. 00 weatherproof or No. 0000 bare will not be more than 12 per cent. which will give sufficiently accurate results.

MINIMUM CIRCUMFERENCES FOR FACTORS OF SAFETY OF 1.33 AND 1.66 EASTERN CEDAR POLES

No. of Conductors	80 FT. SPAN		100 FT. SPAN		120 FT. SPAN		140 FT. SPAN		160 FT. SPAN		180 FT. SPAN		200 FT. SPAN	
	1.33	1.66	1.33	1.66	1.33	1.66	1.33	1.66	1.33	1.66	1.33	1.66	1.33	1.66
30 FT. POLE														
2	22	22	22	22	22	23	23	24	23	25	24	26	24	26
4	24	25	25	26	26	28	27	29	28	30	29	31	30	32
5	26	27	27	29	28	30	30	32	31	33	32	34	33	35
7	28	30	29	32	31	34	33	35	34	36	35	38	36	39
35 FT. POLE														
2	22	23	23	24	23	25	24	26	25	27	26	28	27	29
4	25	27	26	28	28	30	29	31	30	32	31	33	32	35
5	27	29	28	30	30	32	31	33	32	35	33	36	34	37
7	29	31	31	33	32	35	34	36	35	38	37	39	38	41
40 FT. POLE														
2	23	25	24	26	25	27	26	28	27	29	28	30	28	31
4	27	29	28	30	29	32	31	33	32	35	33	36	34	37
5	28	30	30	32	32	34	33	35	34	37	35	38	36	39
7	31	33	33	35	35	37	37	39	38	41	39	42	41	44
45 FT. POLE														
2	25	27	26	28	27	29	28	30	29	31	29	31	30	32
4	29	31	30	32	31	34	33	35	34	36	35	38	36	39
5	30	32	32	34	33	36	35	38	36	39	38	41	39	42
7	33	36	35	38	37	40	38	42	40	43	42	45	43	46
50 FT. POLE														
2	26	28	27	29	28	30	29	31	30	32	31	33	32	34
4	30	32	31	34	33	36	34	37	35	38	37	40	38	41
5	32	34	34	36	35	38	37	39	38	41	39	42	41	44
7	35	37	36	39	38	41	40	43	42	45	43	46	45	48
55 FT. POLE														
2	28	30	29	31	30	32	31	33	31	34	32	35	33	36
4	31	34	33	35	35	37	36	38	37	40	38	41	39	42
5	33	36	35	38	37	40	38	41	40	43	41	44	42	45
7	36	39	38	41	40	43	42	45	44	47	45	48	46	50

NOTES

1.—CONDUCTORS—The above table is to be used for all conductors up to and including No. 1/0 copper and No. 1/0 S.R. Aluminum.

2.—LOADING—Assumed maximum conductor loading—½ in. ice and 8 lbs. wind.

3.—COLUMNS headed 1.33 and 1.66 give minimum circumferences of solid pole in inches at or immediately below the ground line for factor of safety of 1.33 and 1.66 respectively.

4.—SPAN—To obtain span, take the average of the two spans adjacent to the pole.

5.—FIBRE STRESS—This table is based on an ultimate fibre stress of 3600 lbs. per square inch.

MINIMUM CIRCUMFERENCES FOR FACTORS OF SAFETY OF 3 AND 4 EASTERN CEDAR POLES

No. of Conductors	80 FT. SPAN 3	80 FT. SPAN 4	100 FT. SPAN 3	100 FT. SPAN 4	120 FT. SPAN 3	120 FT. SPAN 4	140 FT. SPAN 3	140 FT. SPAN 4	160 FT. SPAN 3	160 FT. SPAN 4	180 FT. SPAN 3	180 FT. SPAN 4	200 FT. SPAN 3	200 FT. SPAN 4
30 FT. POLE														
2	26	28	27	29	28	31	29	32	30	33	31	34	32	35
4	30	33	32	35	34	37	35	39	37	41	38	42	39	43
5	33	36	35	38	37	40	39	42	40	44	42	46	43	48
7	36	40	38	42	41	45	43	47	45	49	46	51	48	53
35 FT. POLE														
2	28	31	29	32	30	33	31	35	33	36	34	37	35	38
4	33	36	35	38	36	40	38	42	39	44	41	45	42	46
5	35	38	37	40	39	43	41	45	42	46	44	48	45	50
7	38	42	40	44	42	47	44	49	46	51	48	53	50	55
40 FT. POLE														
2	30	33	31	34	33	36	34	37	35	39	36	40	37	41
4	35	39	37	41	39	43	40	44	42	46	43	48	45	49
5	37	41	39	43	41	45	43	47	45	49	47	51	48	53
7	41	45	43	48	46	50	48	53	50	55	52	57	53	59
45 FT. POLE														
2	32	35	34	37	35	38	36	40	37	41	38	42	39	43
4	37	41	39	43	41	45	43	47	45	49	46	51	47	52
5	40	44	42	46	44	48	46	50	48	52	49	54	51	56
7	43	48	46	50	48	53	50	56	52	58	54	60	56	62
50 FT. POLE														
2	34	37	36	39	37	40	38	42	39	43	40	44	41	45
4	39	43	41	45	43	48	45	50	47	51	48	53	49	55
5	42	46	44	48	46	50	48	53	50	55	52	57	53	59
7	45	50	48	53	50	56	53	58	55	60	57	62	59	65
55 FT. POLE														
2	36	40	37	41	39	43	40	44	41	45	42	47	43	48
4	41	46	43	48	45	50	47	52	49	53	50	54	51	56
5	44	48	46	50	48	53	50	55	52	57	54	59	55	61
7	48	52	50	55	53	58	55	60	57	63	59	65	61	67

NOTES

1.—*CONDUCTORS—The above table is to be used for all conductors up to and including No. 1/0 copper and No. 1/0 S.R. Aluminum.*

2.—*LOADING—Assumed maximum conductor loading—½ in. ice and 8 lbs. wind.*

3.—*COLUMNS headed 3 and 4 give minimum circumference of solid pole in inches at or immediately below the ground line for factor of safety of 3 and 4 respectively.*

4.—*SPAN—To obtain span, take the average of the two spans adjacent to the pole.*

5.—*FIBRE STRESS—This table is based on an ultimate fibre stress of 3600 lbs. per square inch.*

MINIMUM CIRCUMFERENCES FOR FACTORS OF SAFETY OF 1 AND 2 EASTERN CEDAR POLES

No. of Conductors	80 ft. Span		100 ft. Span		120 ft. Span		140 ft. Span		160 ft. Span		180 ft. Span		200 ft. Span	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
							30 ft. POLE							
2	22	23	22	24	22	25	22	26	22	27	22	28	23	28
4	22	26	23	28	24	30	25	31	26	32	27	33	28	34
5	23	29	24	30	26	32	27	34	28	35	29	36	30	37
7	25	32	27	34	28	36	29	37	31	39	32	40	33	42
							35 ft. POLE							
2	22	25	22	26	22	27	22	28	22	29	23	30	24	31
4	23	29	24	30	25	32	26	33	28	35	29	36	29	37
5	24	30	25	32	27	34	28	36	29	37	30	38	31	40
7	26	33	28	35	29	37	31	39	32	41	33	42	34	44
							40 ft. POLE							
2	22	27	22	28	23	29	24	30	25	31	26	32	26	32
4	24	31	26	32	27	34	28	36	29	37	30	38	31	39
5	26	32	27	34	29	36	30	38	31	39	32	41	33	42
7	28	36	30	38	32	40	33	42	34	43	36	44	37	46
							45 ft. POLE							
2	22	28	23	29	24	30	25	31	26	32	27	33	28	34
4	26	32	28	34	29	36	30	38	31	39	32	40	33	41
5	28	35	29	37	30	38	32	40	33	42	34	43	35	45
	30	38	32	40	34	42	35	44	37	46	38	48	39	49
							50 ft. POLE							
2	24	30	25	31	26	32	27	33	28	34	28	35	29	36
4	27	34	29	36	30	38	31	39	32	41	33	42	34	43
5	29	36	31	38	32	40	33	42	34	44	36	45	37	46
7	31	39	33	42	35	44	37	46	38	48	39	50	41	51
							55 ft. POLE							
2	25	32	26	33	27	34	28	35	29	36	30	37	30	38
4	29	36	30	38	32	40	33	41	34	42	34	43	35	44
5	30	38	32	40	33	42	35	44	36	46	37	47	38	48
7	33	42	35	44	37	46	38	48	40	50	41	52	42	53

NOTES

1.—CONDUCTORS—The above table is to be used for all conductors up to and including No. 1/0 copper and No. 1/0 S.R. Aluminum.

2.—LOADING—Assumed maximum conductor loading—½ in. ice and 8 lbs. wind.

3.—COLUMNS headed 1 and 2 give minimum circumferences of solid pole in inches at or immediately below the ground line for factor of safety of 1 and 2 respectively.

4.—SPAN—To obtain span, take the average of the two spans adjacent to the pole.

5.—FIBRE STRESS—This table is based on an ultimate fibre stress of 3600 lbs. per square inch.

Internal Decay

In a great many cases a pole will not show any signs of external decay but will be hollow, due to internal decay. As this decay takes place where the fibres of the wood are closest to the centre of the pole, the reduction in the strength of the pole is very small as compared to that caused by external decay.

It is a well known fact that for any specified area of material a column is much stronger if made with a hollow section than with a solid section.

The thickness of the shell of a hollow pole can be determined by using an increment borer, and boring one hole on each side of the pole at right angles to the direction of the line so that the thickness may be obtained at the points where the most fibre stress is likely to occur.

In order to determine the strength of a hollow pole in terms of an equivalent solid pole of the same species, curves have been prepared and are included in this paper showing the circumference of solid pole which has the same strength as a particular hollow pole. By means of this curve the tables for solid poles referred to previously may be used to determine the factor of safety of any hollow pole. These curves may be used for all species of poles.

For example, a 30 ft. hollow pole of 40 in. external circumference has a 2 in. shell of sound wood and is carrying 7—No. 0 bare copper conductors at 120 ft. span. Using the curve for hollow pole strength, get the intersection of the 2 in. shell vertical line and the curve marked 40 which corresponds to the external circumference. Then read on the vertical scale the circumference of a sound pole of the same strength as the hollow pole, in this case, 37 in. Referring to the tables it will be seen that a 30 ft. pole of 37 in. circumference carrying 7 conductors has a factor of safety of over 2.

The results obtained from these curves for hollow poles will probably seem unreasonable at first but if the following data is considered the reasonableness of the results must be admitted.

Take the hollow pole above mentioned viz: 40 in. circumference and 2 in. shell. The area of a 40 in. circumference pole when sound is 127 square inches. The area of wood in the hollow pole is 67 square inches. The diameter of pole with 40 in. circumference is 12.75 in. The thickness of wood in hollow pole along the diameter is 4 in.

The thickness of wood along the diameter has been reduced to 31 per cent., but the area has only been reduced to 53 per cent. and the remaining wood is at the maximum possible distance from the centre of the pole. Since the strength varies as the cube of the distance of the fibres from the centre, it can be seen that there still remains in the pole a large percentage of the original strength.

The curve for hollow poles has been carried down to a 1 in. shell. No attempt has been made to limit the minimum thickness of shell which should be allowed. It must be borne in mind that with a shell 1 in. in thickness a small decrease in this 1 in. represents a large decrease in strength and the probabilities are that the

remaining life of a pole with a 1 in. shell is very short.

USEFUL LIFE OF POLES

Any wood pole set in soil will depreciate a certain amount every year. The amount of depreciation will depend on the nature of the soil, weather conditions, etc., but it would be expected that poles cut from the same location, installed at the same time and in the same locality, would have a similar average rate of depreciation.

As an example let us assume that a 30 ft. pole with 6 in. top with a butt circumference at the ground line of 33 in. is carrying 4—No. 6 copper wires at 120 ft. span. Also assume that annual rate of depreciation of butt circumference in this locality is 3/8 in.

As explained previously the load on the pole would be the bending moment on the pole due to pressure of the wind on the pole and wires under the assumed loading conditions.

Due to pressure on pole =

$$\frac{8 \times 24.5 \times 24.5 \times (10.5 + 2 \times 6)}{72}$$

= 1500 ft. pds.

Due to pressure on wires = $4 \times 24.5 \times 0.775 \times 120 = 9100$ ft. pds.

Therefore total bending moment = $9100 + 1500 = 10600$ ft. pds.

Resisting moment of 33 in. Eastern Cedar pole = $0.0002638 \times 3600 \times 33^3 = 34150$ pd. ft.

Therefore factor of safety new =

$$\frac{34150}{10600} = 3.2$$

If this pole were allowed to depreciate until the remaining strength was 10,600 ft. pds. or factor of safety of 1, the residual circumference would be,

$$.0002638 \times 3600\ C^3 = 10600$$

$$C = \sqrt[3]{\frac{10600}{.0002638 \times 3600}} = 23 \text{ ins.}$$

Therefore life of pole at 3/8 in. depreciation per year =

$$\frac{33-23}{3/8} = \frac{80}{3} = 27 \text{ years.}$$

Let us now assume that, instead of four wires, 12—No. 6 copper wires are placed on these same poles with same span.

Load on wires = $12 \times 24.5 \times 0.775 \times 120 = 27324$ ft. pds.

Windage on pole = 1500 ft. pds.

Total load = 28824 ft. pds.

$$\text{Factor of safety new} = \frac{34150}{28824} = 1.2$$

This pole would depreciate to factor of safety of 1 when resisting moment of pole was reduced to 28824 pd. ft., or if C = circumference for 28824 pd. ft. then $0.0002638 \times 3600\ C^3 = 28824$ pd. ft.

or C = 31 in.

$$\text{Life of pole} = \frac{33-31}{3/8} = 5 \text{ years.}$$

The above examples are worked out to show the advantages that may be gained in the life of the poles by using large butt circumference, providing the increase in initial cost is not too great. An attempt to obtain too long a life should not be made as this may not be realized due to obsolescence of existing equipment. No attempt will be made here to compare the annual carrying charges on two poles of different butt circumferences but the above example will serve to show that there may be a considerable saving through the use of the larger butt pole.

ECONOMICAL SPAN

The rate of annual depreciation which should be set up for a line depends on the life of the equipment. In the case of wood poles, the life depends, among other features, on the nature of the soil in which they are erected, for example, poles erected in light sand deteriorate more rapidly than poles set in clay or rock.

An attempt is made below to determine the most economical span to use for different conditions under assumed annual rate of decay for the province of Ontario. For purposes of calculations, the rates of deterioration of poles is divided into four classes as follows:

(a) *High* A depreciation of 0.6 in. per year in the circumference of sound wood at the ground line.

(b) *Average* A depreciation of 0.4 in. per year in the circumference of sound wood at the ground line.

(c) *Low* A depreciation of 0.2 in. per year in the circumference of sound wood at the ground line.

(d) *Rock* Using a depreciation similar to (c).

While the above rates of deterioration are arbitrarily chosen, it is believed that they fairly well represent actual conditions in this province.

It is also assumed that, in each case under consideration the poles will be replaced when the factor of safety has been reduced to one under heavy loading conditions.

CAPITAL COST

The capital cost is based on the cost of poles erected with necessary crossarms, pins and insulators for lower voltage circuits and with all standard overheads included. A small allowance has been made for probable lower labor cost for poles in poor soil and for additional cost for poles in rock.

CARRYING CHARGES

The annual charges are based on the following:—

(a) *Interest* At the rate of 5 per cent. per annum on the capital.

(b) *Depreciation* At a rate which when compounded at 4 per cent. will replace the capital at the end of the estimated life of the various types of poles.

(c) *Sinking Fund* At a rate which will retire the original capital in 40 years.

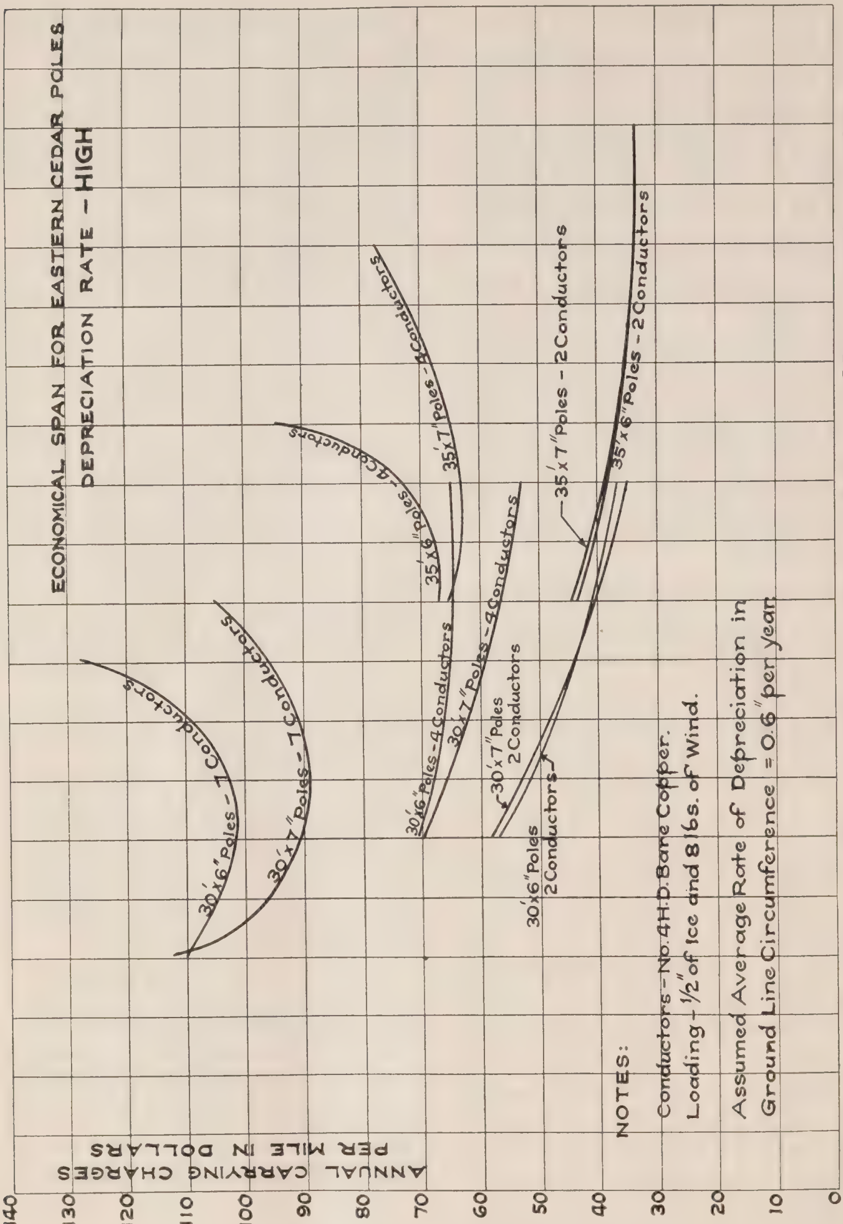
(d) *Contingencies* At 0.25 per cent. in each case.

In addition to the above, annual carrying charges should include maintenance and other operating charges. As these vary so much with different utilities, they have been omitted in the calculations.

ESTIMATED LIFE OF POLES

The estimated life of the poles in each line is determined by calculating the circumference of pole required for a factor of safety of one and, by using the average circumference of each class of pole, the life is calculated with the above mentioned rates of depreciation, for example:

The total bending moment on a 30 ft., 6 in. top pole carrying 4 No. 4 h.d. bare copper wires at 150 ft. span is 14,300 ft. pds. For a factor of safety of one, this requires an Eastern

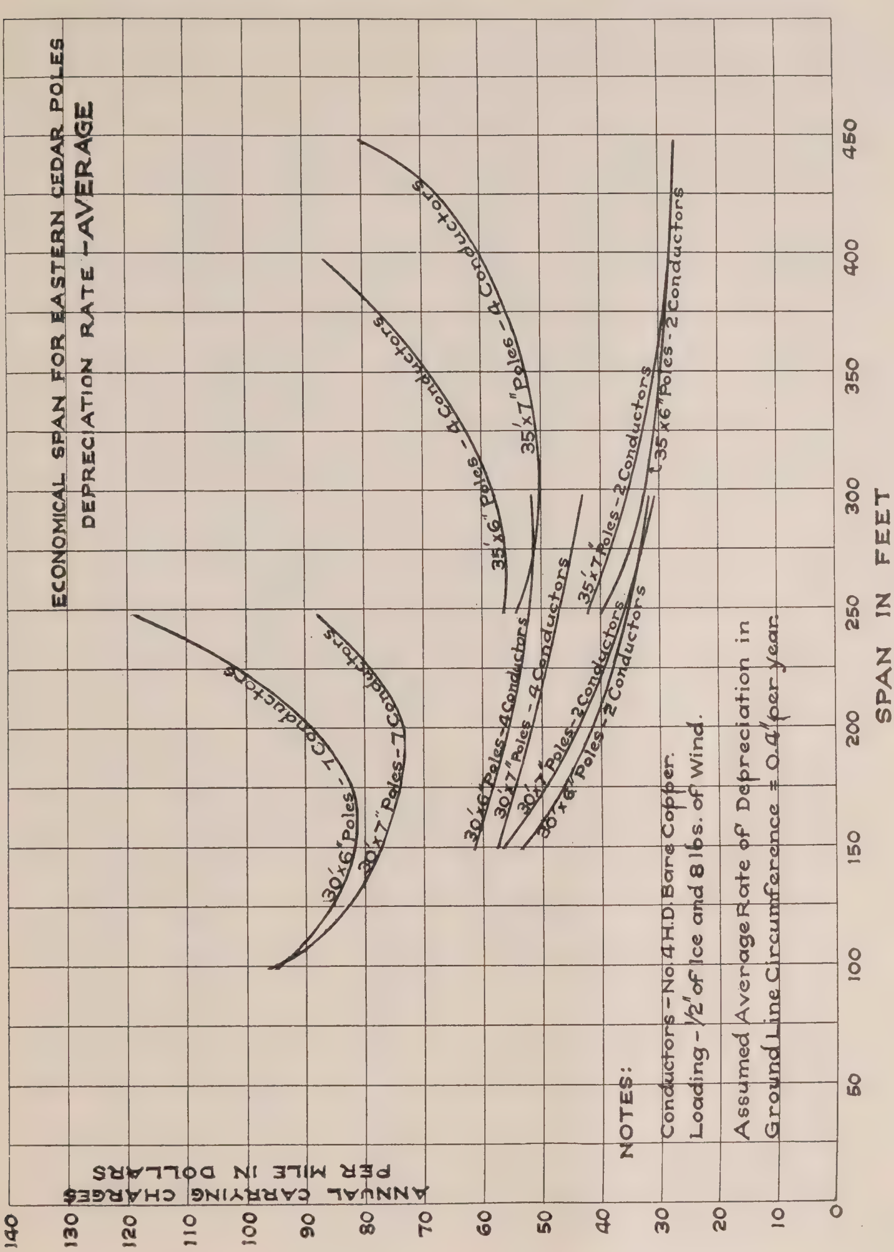


Cedar pole of 25 in. circumference at the ground line. The average ground line circumference for a new 30 ft., 6 in. top Eastern Cedar pole is 35 in.

The life of the pole will then be the time it takes to depreciate from 35 to 25 in. in circumference, as follows:—

At 0.6 in. per year life

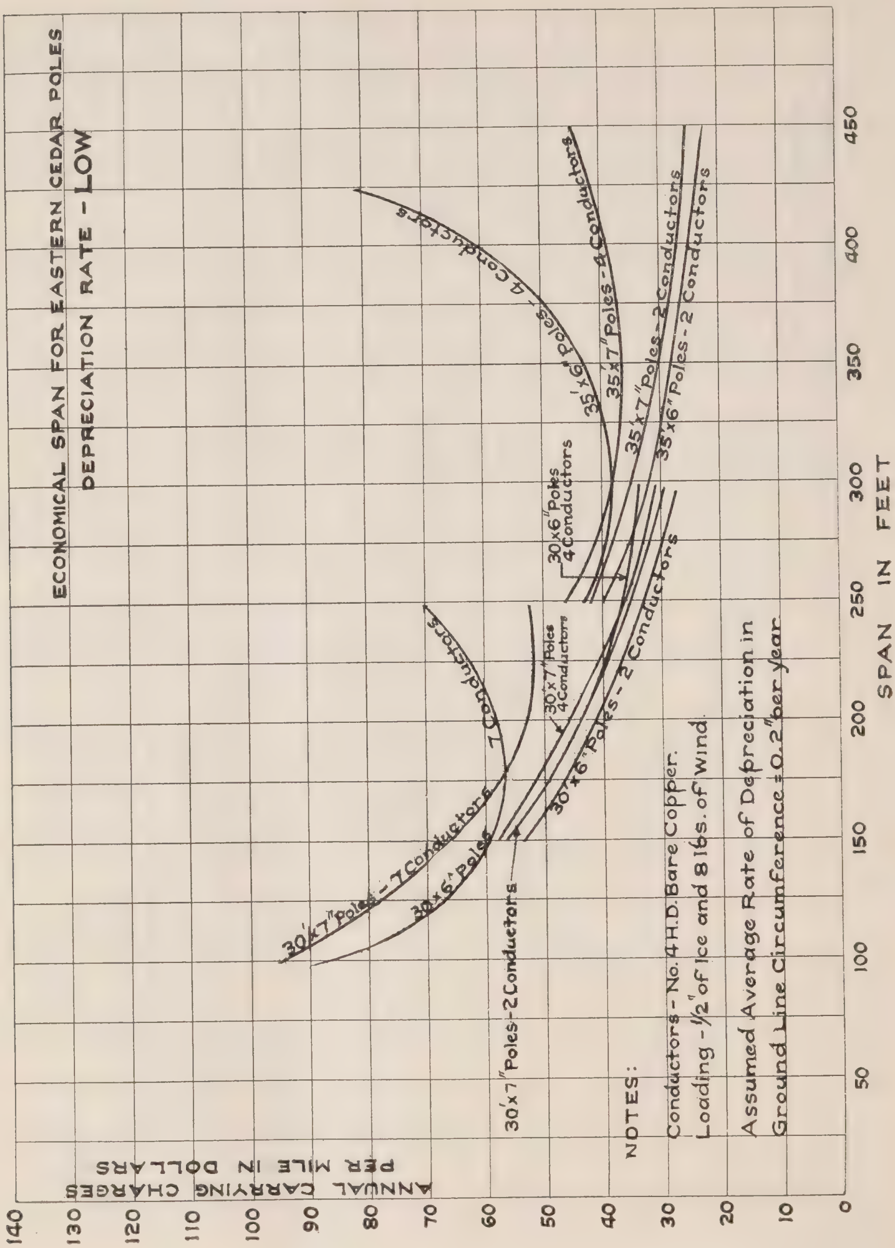
$$\frac{10}{0.6} = 16.7 \text{ years}$$



At 0.4 in. per year life $\dfrac{10}{0.4} = 25$ yrs.

At 0.2 in. per year life $\dfrac{10}{0.2} = 50$ yrs.

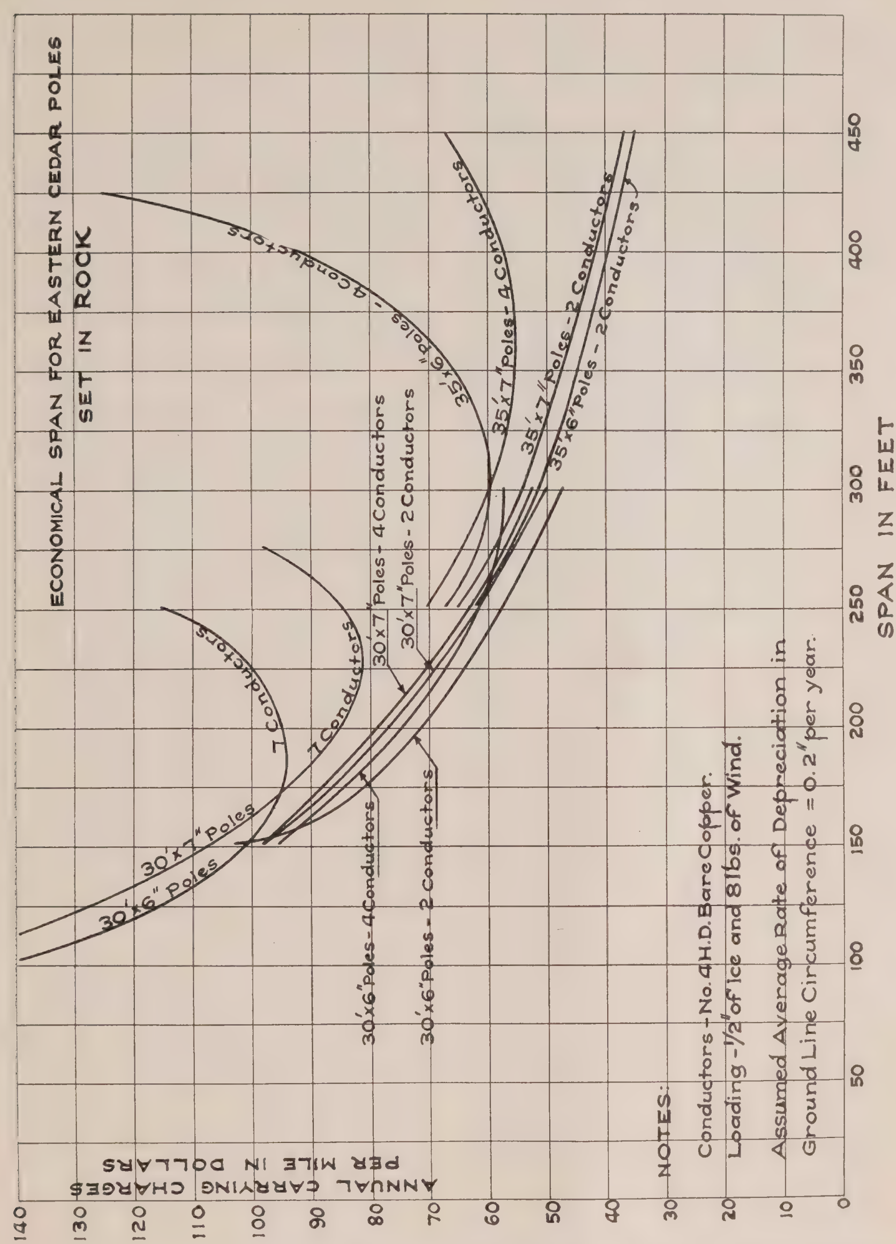
A maximum life of 30 years is used in determining the rate of depreciation as longer life may not be realized due to obsolescence and other like causes.



CURVES

The four groups of curves shown indicate the variation in annual carrying charges per mile of line for 30 ft. poles carrying 2, 4 and 7 conductors and 35 ft. poles carrying 2 and 4 conductors for various spans and classes of soil.

The 30 ft. pole curves have been carried to 300 ft. span only as this is



the maximum that could ordinarily be used on account of ground clearances. The 35 ft. pole curves have been shown from 250 feet to 400 or 450 feet. Under ordinary conditions the 35 ft. poles could be used within this range of spans.

The choice of span may depend on other factors than economy. In towns the location of street inter-

sections, lot lines and services is usually the determining factor. When the span is limited by the above considerations, it will be found economical, in certain cases, to use lighter poles than are commonly used.

A study of the curves indicates that the greater the number of conductors the sharper the curve obtained. This indicates the necessity of greater care in the selection of spans for the heavily loaded lines. For example, on the group of curves for average rate of depreciation, the most economical span for 7 conductors on 30 ft., 7 in. top poles is 190 feet. It is common practice, usually determined by other conditions, to build lines of 7 conductors (say primary and secondary) at 125 ft. span. However if local conditions permit, a saving of $9.00 per mile or 11 per cent. in annual carrying charges can be made if the span is lengthened to 190 feet. Similarly for 4 conductors on 30 ft., 6 in. top poles. In the past, it has been common practice to use 150 feet span. If the line is constructed at 275 ft. span instead of 150 ft., the saving in annual charges would be $10.00 per mile or 20 per cent.

CONCLUSIONS

From the above discussion and examples the following points in connection with the construction and maintenance of wood poles may be noted.

1. The loading on a pole depends on the number of conductors and other attachments, the height of the pole and the ice and wind load on the conductors, poles and other attachments.

2. The strength of wood poles is proportional to the cube of the circumference.

3. There is a wide divergence of opinion as to necessary factors of safety in poles for various conditions.

4. Open wire telephone circuits impose a much greater load on poles than the equivalent circuits in cable.

5. Depreciation of external circumference of pole causes a greater decrease in strength of poles than is caused by internal depreciation.

6. The fact that a pole is hollow is not sufficient to justify its replacement. The pole may still retain most of its original strength.

7. There is an advantage to be gained in using poles of large butt circumference provided the initial cost of the lines is not increased to too great an extent.

The information contained in this paper, cannot be used as inflexibly as it could were the material of more uniform strength but may be used in conjunction with knowledge gained through experience in the maintenance of wood pole lines.

Association of Municipal Electrical Utilities

Minutes of Convention

The thirty-third Convention of the Association of Municipal Electrical Utilities was opened at the Prince Edward Hotel, Windsor, at 9.30 a.m. on Thursday, June 22nd, 1933, with the President, T. W. Brackinreid in the chair.

The business of the session was proceeded with immediately and Mr. S. K. Cheney, Distribution Section, Electrical Engineering Department, Hydro-Electric Power Commission of Ontario, presented a paper "Wood Poles—Loading and Strength". Discussion following this paper was by Messrs. C. E. Myers, R. L. Dobbin and Joseph Showalter. Mr. Wilson J. Wylie, Power Department, Toronto Hydro-Electric System, presented a paper "The Starting of Polyphase Induction Motors from the Electric Utility Viewpoint. There being no discussion on Mr. Wylie's paper, the session then adjourned.

At 12.30 p.m. this Association met with the Ontario Municipal Electric Association for the first convention luncheon. The President, Mr. T. W. Brackinreid, as toastmaster, introduced His Worship Mayor R. A. Farrow of Walkerville, who extended a welcome to the delegates of both Associations to the Border Cities. Mr. C. A. Maguire, President, Ontario Municipal Electric Association, replied, thanking the Mayors of Walkerville and Windsor for their very splendid and warm welcome, and the manner in which they received the delegates as they entered the city.

Mayor Farrow then introduced the guest speaker of the luncheon, the Right Honourable Arthur Meighen, P.C., K.C., Commissioner, Hydro-Electric Power Commission of Ontario, Mr. Meighen's address was on the right of property.

During this afternoon the delegates of both Associations were entertained by a special complimentary bus trip through the Border Cities and Detroit, as guests of the Border City Electric Utilities.

At 6.30 p.m., the delegates met with the Ontario Municipal Electric Association for the convention dinner, with Mr. C. A. Maguire, President, Ontario Municipal Electric Association, in the chair. Musical entertainment that was very much appreciated was provided by the Border Scottish Choir of 150 voices under the direction of H. Whorlow Bull. His Worship D. A. Croll, Mayor of Windsor, introduced Reverend M. S. Rice, Detroit, Michigan, the speaker of the evening.

The second convention session opened at 10.00 a.m. on Friday, June 23rd, with the President in the chair.

Mr. A. J. Magley, Chief Engineer, Moloney Electric Company of Canada, Limited, Toronto, presented a paper—"The Operating Costs of Transformer Losses". Discussion following Mr. Magley's paper was by Messrs. J. E. B. Phelps, Joseph Showalter, G. A. Brace, H. F. Shearer, and E. V. Buchanan.

"Hot Water", a comedy in one act by J. Arthur Nichols, Walkerville

Hydro-Electric System, was presented by a cast of six, depicting what might occur in any average home where water is not heated electrically.

Mr. R. T. Jeffery, Chief Municipal Engineer, Hydro-Electric Power Commission of Ontario, addressed the session giving a review of the Water Heater Campaign. Discussion following Mr. Jeffery's address was opened by Mr. I. Pritchard, but as time would not permit further discussion it was deferred until the session of the following morning.

The session then adjourned.

At 12.30 p.m. the delegates met with the Ontario Municipal Electric Association for the second convention luncheon when Mr. T. W. Brackinreid, President Association Municipal Electric Utilities, took the chair. His Worship Mayor A. J. Reaume of Sandwich introduced the guest speaker, Mr. J. H. Rodd, K.C., Windsor.

At 2.30 p.m., the third convention session opened which was conducted by the Committee on Accounting and Office Administration. The Report by the Committee on this meeting is as follows:

> "Arrangements were made by the Committee on Accounting and Office Administration whereby an exhibit of office equipment was set up. This exhibit was composed of billing and addressing machines, typewriters, adding machines, filing equipment, furniture and modern visible records and an effort was made to set up a small model Hydro office. The Committee, however, was not able to carry this idea through the whole convention session because of the number attending the exhibit and the limited space that they had to work in. However, it was felt that the exhibit was well worth while and numerous favourable comments were heard concerning it.

"On Friday afternoon, June 23rd, at 2.30, the Committee arranged an informal session of those present and about one hundred and twenty-five representatives of various utilities attended. Mr. W. G. Pierdon, the Chief Accountant of the H.E.P.C., addressed the meeting giving an outline of some phases of the Commission's financial arrangements as affecting the local utility. This address brought to those present additional information as to the co-operative features of the Commission's financing as well as enlarging on some of the more familiar aspects of this phase of the Provincial Commission's business and Mr. Pierdon's presence at this meeting was very much appreciated.

"Provision was made for discussion on accounting matters and several of those present availed themselves of the opportunity of obtaining necessary information but owing to the extreme heat and the crowded condition of the room the meeting was not prolonged.

"Several secretaries and accountants of local commissions were introduced to the meeting as well as the representatives of some of the equipment manufacturers and appreciation was expressed of the work of the representatives of the various manufacturers exhibiting their products and assurance of further co-operation was given by them.

"The Committee is planning

several sectional meetings of a similar nature to be put on before the annual meeting in January. It has been suggested that in all probability one will be held in the eastern part of the Province and another one in the northern part of the Province if satisfactory arrangements can be made."

The fourth convention session opened at 9.30 a.m. on Saturday, June 24th with the President in the chair.

Immediately after opening the President asked for discussion on Mr. R. T. Jeffery's address of the previous morning on "A Review of the Water Heater Campaign", but there was no discussion offered.

Mr. R. E. Jones, Distribution Section, Electrical Engineering Department, Hydro-Electric Power Commission of Ontario, showed a film illustrating the action of various types of fuse switches.

Before proceeding with the presentation of the paper by the Committee on Grounding of the Hydro-Electric Power Commission of Ontario, entitled "Grounds", Mr. Wills Maclachlan, Chairman of the Committee showed a film illustrating a safe method of unloading poles from railway cars. Discussion following the paper on "Grounds" was by Messrs. Joseph Showalter, E. I. Sifton, C. E. Schwenger, H. H. Pegg, E. V. Buchanan, R. E. Jones, O. H. Scott, O. V. Anderson, and M. W. Rogers.

The Convention then adjourned.

The register shows a total of 524 delegates to have attended the Convention, classified as follows:

Class A.........	107
" B.........	264
Commercial.....	80
Associates.......	35
Visitors.........	38

There were 470 present at the convention luncheon of the first day and 428 at that on the second. The attendance at the convention dinner totalled 447. The hotels reported a total of 559 guests belonging to the convention party, in addition to which there were approximately 100 in attendance from immediately adjacent municipalities.

THE BULLETIN

Published by
HYDRO-ELECTRIC POWER COMMISSION
of Ontario

620 University Ave.
Toronto

Subscription Price $2.00
Per Year

Kitchener Public Utilities Commission's New Office Building

ONE of the most substantial and serviceable structures of its kind in the province, Kitchener's new public utilities building, King and Gaukel Streets, was officially opened on June 1, 1933, and is now occupied by the local staff, which includes the gas, electric and street railway departments.

Indicative of the growth of the electric and gas utilities under public ownership and the decision to prepare for future needs, in a period when construction costs are low, the new structure has been designed to ensure, first, efficiency in service to the consumer and patrons, and, second, the most economic operation. The building is another outstanding mile-post in the commission plans to take care of the demands of the business since the citizens took over the utilities about 30 years ago.

The general architectural scheme of the building, which is fireproof and cost about $100,000, is of the modern type and based on the idea of ensuring the maximum amount of light in all working space. The structure, 46 feet by 96 feet, is of three storeys with basement. The foundation is of reinforced concrete supporting steel frames which are designed for three additional storeys.

The walls between the basement and the window sills of the first floor are of Stanstead (Quebec) granite. The super-structure is of Queenston limestone and the walls are backed up with local tile.

The ground floor, the two entrances to which are from King Street, will be devoted to general offices, cashiers' wickets, offices of the manager and assistant manager, drafting room, and Hydro shop.

The floor of the section to be used as a Hydro store is of travertine with dado of Belgian black and botticino marble. The floor elsewhere on the main storey is of rubber. The walls are light buff and ceiling is of cream color.

Doors and frames are of steel. A feature is the two tellers' cages built without tops in accordance with the latest practice.

To make it unnecessary for a consumer to go to the accounting

CONTENTS

Vol. XX No. 9

September, 1933

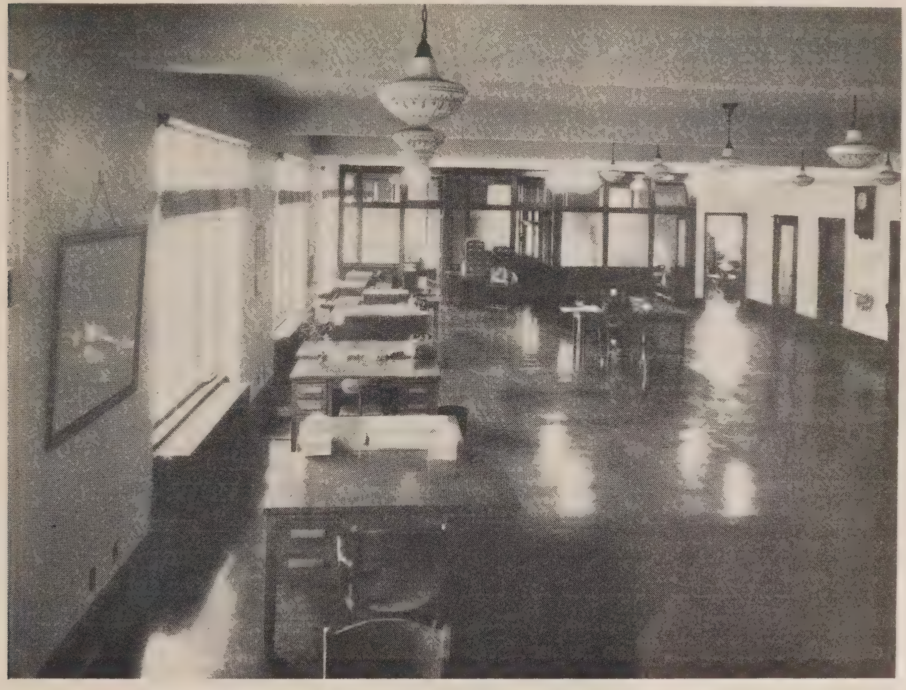
department on the second floor a card elevator has been installed on which the consumer's account can be brought down from the second to the first floor.

An elevator of the latest automatic and safe type has been installed. This can be operated by the passenger himself. Steel stairways also have been provided.

Another feature is the large centre window on the King street elevation provided for display purposes.

The second storey will be used for general office purposes by the accounting department. Consumers' and general operating accounts will be looked after by the clerks and bookkeepers on this floor. Here also are

Hydro Shop and General Office.



Accounting Office on second floor.

the office of the secretary-treasurer, the auditor's room and the board room. Another feature is the especially constructed room for the addressograph and the coin-counting room of the street railway department. Acoustic plastering was used in this room so that all sounds will be deadened and there will be no interference or distraction as far as the general offices are concerned.

The flooring on this storey is linoleum. The partitions and trim are of plain oak. The boardroom is panelled in Canadian black walnut, with plain oak flooring in basket weave pattern. The enrichments in the panel are fibre ornaments.

The third storey for the present will be devoted to private offices, of which there are five. The modern vault accommodation on each floor is another feature.

Two pent houses on the roof have been provided in connection with the ventilation system and the automatic elevator control.

The basement will be used for storage needs of the Hydro shop, for the demonstration of electrical and gas appliances and for periodical lectures on their use.

The heating system is the forced hot water circulating one, using an electric boiler. The heat is stored in a large insulated tank, having a capacity of 1,150 gallons. There is a total connected load of 210 kilowatts, 550 volts, three phase, consisting of 21 ten kilowatt, 550 volt units.

The temperature of the water is automatically controlled. The forced

circulation is obtained by the installation of a centrifugal circulating pump.

The tank was designed to hold enough stored heat in the heater to provide for a peak power period on the system of maximum of three hours. The substation operator at the power plant on Gaukel Street, about 500 feet from the offices, by means of a push button can take the heating system off the line during the peak power period.

The automatic control over the temperature of the building was put to thorough tests last winter and proved successful.

While the general contract for the building, designed by B. A. Jones, architect, Kitchener, who supervised the construction, was let to W. H. Yates Construction Company, Limited, Hamilton, the majority of the workmen engaged on the building during the past 12 months were Kitchener citizens. The sub-contractors also were local, excepting in instances where the material needed was not made there.

The Kitchener Public Utilities Commission for this year, and under whom the building was brought to completion, consists of David Gross, chairman; N. Asmussen, P. McNulty, and Charles H. Doerr, Commissioners; and H. W. Sturm, Commissioner and Mayor. V. S. McIntyre is Manager. We extend every good wish for the success of the Commission and staff in their handsome new quarters.

Georgian Bay Municipal Electric Association Annual Meeting

THE first annual meeting of the Georgian Bay Municipal Electric Association, since its formal organization last Fall, was held at Owen Sound on Wednesday, September 13th, in the auditorium of the City Hall. The general afternoon meeting was called for two o'clock, and delegates were present from all parts of the Georgian Bay system. All three members of the Hydro-Electric Power Commission of Ontario and several executive officers of the Commission's staff attended the meeting, and manufacturers' representatives from Toronto, Hamilton and Kitchener were also present. At the rear of the hall were quite a number of manufacturers' exhibits of electrical equipment. These exhibits came in for much favourable comment from the delegates prior to the opening of the meeting and at its conclusion.

Mayor Thompson of Owen Sound welcomed the delegates to Owen Sound at the opening of the meeting, stating that lately much effort has been made to make Hydro a political issue, but declaring that the accusations came from those who knew the least about the institution they were criticising.

Mr. W. H. Gurney of Wingham, president of the Association, occupied the chair throughout the meeting. He expressed his pleasure in seeing

so many delegates present. He complimented the Ontario Commission on its handling of the exchange question and spoke optimistically regarding the prospects of general business improvement in the near future.

Secretary-Treasurer Herman Denef of Hanover, read the minutes of the 1932 General Meeting and of the subsequent executive meetings and made a report of the various correspondence that the Association had had as a result of these meetings. The treasury has a balance of cash on hand of $39.36.

All of the officers were re-elected for another year, it being the feeling of the meeting that they had given the Association very effective leadership during the first year of its existence, and in order that they may put to good use the valuable experience gained during the past year. The list of officers is as follows:—President—W. H. Gurney of Wingham; 1st Vice-President—J. R. McLinden of Owen Sound; 2nd Vice-President—David Hurrie of Midland; Secretary-Treasurer—Herman Denef of Hanover; Executive—John Kalte of Hanover, A. Menary of Grand Valley, Dr. G. S. Fowler of Teeswater, Dr. J. F. Marcus of Kincardine, G. Welsh of Sunderland, R. J. Beaubien of Penetang and H. E. Prentice of Collingwood.

After the disposition of general business, and the election of officers for the ensuing year, the meeting was thrown open for the discussion of various Hydro matters of importance and interest to the municipalities comprising the Georgian Bay system. Questions were introduced by the various delegates, and answered by the various members of the Hydro-Electric Power Commission, and by members of the Commission's Engineering Staff present, the press summary of the proceedings being as follows:

> "The meeting was of a lively nature. It was not of the back patting, mutual congratulating kind, and the delegates were by no means inclined to take Hydro for granted. A number of pointed questions regarding Hydro Administration were asked during the afternoon, all of which were given careful and courteous answers by one of the Hydro-Electric Power Commission representatives present, usually Dr. Gaby."

The first of the questions was introduced by Mr. D. Hurrie of The Midland Public Utilities Commission, as follows:

> "Last year when the exchange question was to the fore, the question was asked,—Why not meet the exchange charges from the Reserve Funds? And the Commission answered that these funds had been set up for a specific purpose and could not be touched. Yet in the Hydro Blue Book for 1932 it is shown that the sum of over $3,000,000 was drawn from that same obsolescence fund for the Niagara System and various charges taken out of it. Losses due to flat rate contracts amounting to something like $2,900,000 were taken out of reserves in the Niagara District for the first time, although in the Georgian Bay District we had to take care of such losses ourselves. Exchange was taken out—well, we have no quarrel with

that. But, $560,000 was also taken out and given to the municipalities by way of what might be called a hand-out. On top of that, all payments in the Niagara District were foregone for the first time. But in the Georgian Bay District we had to come across. It was a case of 'business as usual' with us. In short, it seems that a state of financial stringency becomes a contingency in Niagara District and is met out of the contingency fund, but, in the Georgian Bay District it is not a contingency. There seems to be a geographic aspect to it. We are just as financially embarrassed, just as hard hit in the Georgian Bay District as the Niagara District."

In reply, Dr. Gaby stated that there was no connection between the obsolescence and contingency fund of the Niagara system and the Georgian Bay system, each of the various reserve funds set up on each system having its own purpose related to the requirements of the system. For example, the renewal reserve on each system was provided for the replacement of worn-out equipment of that system at the end of its useful life. Respecting the reserve for obsolescence and contingencies, the contingency fund, he explained, was a form of insurance against accidental damage to lines and other equipment, whereas, the obsolescence fund was created as a means of replacing obsolete equipment at various times for the purpose of keeping the Hydro developments and plants up-to-date. In addition to these various reserves, a $10,000,000 reserve had been set up on the Niagara system for the purpose of stabilization of rates, due to the fact that the total cost of power generated and purchased was necessarily fixed by provisions that must be made in advance, but the amount of power actually utilized from year to year would depend upon general business conditions that could not be foreseen with precision. It was from this stabilization portion of the Niagara system reserve for obsolescence and contingencies that the amounts mentioned by Mr. Hurrie had been taken. On the Georgian Bay system, with its more flexible provisions for power supplies, no such stabilization reserve had been set up.

Mr. J. H. Kalte of The Hanover Public Utilities Commission presented the next question, and addressed the meeting with regard to what he claimed "discrimination in Hydro rates" and he asked why Southampton, for example, should be given a cheaper street lighting rate than Hanover.

Dr. Gaby replied to Mr. Kalte that street lighting rates, as well as rates for industrial purposes, and for domestic and commercial lighting consumers were governed largely by local conditions, which were peculiar to each municipality. He pointed out that the cost of Hydro power to the municipality of Southampton was considerably greater than was the cost at Hanover, but that the number of lights, the type of street lighting, the area covered and many other items were local factors which vary greatly in different towns.

Mr. H. Denef, Superintendent of The Public Utilities Commission of Hanover, enquired regarding the use of Diesel engines, and he informed

the meeting that salesmen calling on the various municipalities were responsible for the statement that cheaper power could be produced by such means than could be obtained from Hydro.

Dr. Gaby replied to Mr. Denef, and informed the meeting that the investigation of Hydro engineers as to the relative merits of various types of prime movers such as steam, Diesel oil engines, and hydro-electric power, proved hydro-electric power to be considerably cheaper than power produced by any other method.

Mr. John Carlton of The Beeton Hydro-Electric Commission then addressed the meeting, expressing the opinion that since Hydro was a public enterprise, the same rates should be charged in all municipalities, irrespective of their distances from the source of supply. He stated that power should be sold on the same basis as the Post Office service, which takes a letter anywhere for 3c. If there cannot be the same price to each municipality, surely there can be such to each system, he is certain.

Dr. Gaby in reply, stated that it would be grossly unfair to ask municipalities such as Toronto, Hamilton, or Owen Sound to pay the cost of Hydro extensions for new districts where the population was small and the cost for supplying Hydro necessarily high. The cost of Hydro power at the generating plant in each system was the same to all municipalities, but the cost of transmission from the developments to the municipalities, as well as transformation at the municipal boundaries, and the distribution inside of the latter, was the cause of the varying cost to the various communities. The effect of a flat rate to all municipalities would be an increase in rates to all of the larger municipalities. The Right Honourable Arthur Meighen in the course of an address made later in the afternoon, also referred to the question of flat rates. He reviewed the origin of Hydro, when the thirteen municipalities had united in a public-owned system. Naturally, none were willing to pay more than power was costing under private ownership, in order that power might be carried to some more distant municipality; consequently, a policy was adopted of charging each municipality the actual cost of supplying same with Hydro power. "On that rock", stated Mr. Meighen, the whole Hydro organization was constructed; since then, it has spread until some 700 odd municipalities are now served. If, after all of the municipalities have entered the scheme on a cost basis, the government steps in and breaks the agreement, and charges one municipality with the cost of another, such procedure would be confiscation, and confiscation of the blackest and meanest kind. Referring to the flat rate of the Postal Department of 3c. per letter, he explained that the Department was in a different class of business, and that its operation has been started in that manner. You cannot ship freight on the C.N.R. as cheaply to Vancouver as from Toronto to Owen Sound. The Railroad Company would not last a week under such circumstances. In the case of Hydro also, if it were operated on a flat rate basis, it would be apparent within a week that it could not be kept going.

Mr. Hurrie had difficulty in reconciling a statement by Dr. Gaby that there was no surplus power on the Georgian Bay system, with the fact that the water-heater campaign was to provide consumption of surplus power. Dr. Gaby referred to the fact that the Georgian Bay system had to buy power from the Niagara system to supplement its own power output. While there is no surplus power on the Georgian Bay system, there is an interconnection with the Niagara system, on which system a certain amount of temporarily idle reserve power exists, and which is available to the Georgian Bay system consumers, who can participate in the economic saving through installation of water-heaters. Water-heater load is equivalent to domestic or power load in that its rate provides for the payment for power at cost. With reference to the estimated reduction in cost mentioned by Mr. Hurrie, Dr. Gaby pointed out that increased load meant increased use of transmission lines, and therefore a reduction in the cost per horsepower to all municipalities.

The next question on which the meeting desired information was again introduced by Mr. Hurrie, and he requested information concerning the varying share of capital which each municipality assumed each year. He stated—quoting from the Annual Report of the Hydro-Electric Power Commission—that in 1930 the Town of Midland was responsible for a capital share of $780,000; in 1931 of $700,000; and in 1932 of $720,000. "What we want to know is, how were these charges apportioned? Or, is it a hit-and-miss affair?" he asked.

Dr. Gaby replied that there was no "hit-and-miss" calculation in determining the cost of power, or in apportioning capital, under the Hydro administration. Nearly three months' work is required to apportion charges amongst all the municipalities, and the calculations are carefully checked by the Commission's auditors. Midland's share of capital had varied from year to year, due to the fact that such was determined on the actual horsepower demand of the municipality. This demand had varied very sharply from year to year during the past two or three years, consequently, Midland's capital would vary correspondingly.

At the morning meeting of the Executive Committee, a resolution was passed asking a concession from the Commission in the nature of granting rural customers a 5-year term contract instead of 20-years. The resolution stated that such a concession would result in many more farmers using Hydro service, and would help to use up surplus power.

The Honourable J. R. Cooke, Chairman of the Commission, replied to this question. He stated that the 20-year contract had been provided for the protection of the rural consumer himself. Illustrating how the 20-year contract,—by giving each prospective consumer assurance that future costs will not rise because of failure of other consumers to continue their support,—had promoted rapid extension of rural electrification, Mr. Cooke reminded the delegates that the policy of delivering rural power on an extensive scale had been instituted for only ten years, yet, at the present time there were some 60,000 rural

customers in Ontario served under 20-year contracts. When power was first delivered in rural districts the service charge was $7.00 per month, whereas to-day it was $2.50 per month, consequently, it could never be said that rural distribution of electrical energy was a failure. The rural customer could not be given the same rate as the urban customer on account of distribution problems, there being in all probability in the neighbourhood of 100 consumers per mile of line inside of urban districts, whereas, in rural districts service is given when only three farm contracts per mile of line can be secured. Under such circumstances, the fixed charges on these distribution lines would be divided by three in the case of the farmer, and by 100 in the case of the urban consumer. When the three farmers sign for Hydro power, the revenue for carrying the mile of line must come from each of them, if one drops out, the carrying charges on the investment would have to be carried by two, and the cost to these two consumers would naturally increase; consequently, 20-year contracts were a protection to the rural consumers, encouraging them to take the service.

Mr. Cooke then went on to state that the great difficulty in electric service in Ontario is not "electricity", but the cost of money invested in the project.

In response to a special request by the delegates the Right Honourable Arthur Meighen addressed the afternoon meeting of the Association. He stated that the Hydro was a gigantic organization, both in the amount of money involved,—it is a $383,000,000 investment—and with respect to its area of operation. Hydro is a pioneer of the whole world in its attempt to control, by the people, a business factor extending over the whole province. The C.N.R. is the nearest comparison. In point of view of size, the C.N.R. is larger, but, in operation, there is no comparison. The C.N.R. only carries goods. The Hydro carries power, but, it also develops it. It is making new investigations daily, and it operates in contract with a tremendously large number of municipalities. Again, without assigning the blame, we cannot boast of the success of the C.N.R. But, without assigning the credit, we can boast of the success of Hydro.

After a brief address by Commissioner C. A. Maguire, President of The Ontario Municipal Electrical Association, the meeting adjourned.

At 6 o'clock in the evening, a Convention dinner was held at the Owen Sound Golf & Country Club, the Chairman of the meeting being Mr. C. J. Halliday of The Chesley Public Utilities Commission.

At this Convention dinner Mr. T. J. Hannigan of Guelph, Secretary of The Ontario Municipal Electrical Association, gave a short address on the origin of Hydro; and the speaker of the evening was the Right Honourable Arthur Meighen, who discussed conditions leading up to the present world depression, and the industrial revolution which must be faced in connection with a machine age.

On the invitation of Mayor David Williams of Collingwood, the Association decided to hold its meeting next year in that municipality.

Domestic Water Heating by Furnace Coils

THE heating of water for domestic use by coils in furnaces is a timely subject, as it is at this period of the year that house-heating furnaces are started for the cold season. No doubt many of the Commission's consumers are still using furnace coils for domestic water heating, believing it to cost little or nothing to do so. The Editor of *Electrical Digest* has handed to us an article showing the results of some tests made by Professor B. L. Steele, of Washington State University.

The Professor Steele Article

During the halcyon days of years but a few past, those living in the older countries of the world may well have been impressed by the apparent disregard of all principles of thrift as displayed by those on this continent. Conditions have changed and we are much more of the 'domestic economist' in every sense of the word, for need's must when the devil drives.

Seeking out the elusive extravagance in domestic arrangements has become a science to many but in spite of that they sometimes leave off several feet above what is the actual rock bottom of possibilities. There is, for example, and idea in the minds of many that the heating of the domestic supply of water can be accomplished at no cost by the use of a common water coil placed over the fire bed, the water being stored in an uninsulated tank alongside the furnace. It might, therefore, come as a surprise to these people that this water, instead of being "velvet", to use a colloquialism, is costing real dollars and cents in extra coal or fuel consumed in heating it.

In such installations the summer supply of hot water is usually provided by an auxiliary gas heater, whose cost of operation is also a definite amount. Adding the winter and summer costs of water heating by such media, it might come as a further surprise that the yearly expenditure would not only amply cover the cost of electrically heated water, but would take care of their needs in a cleaner, simpler, and more satisfactory manner.

During last year Professor Steele, of the Washington State University, made actual tests of the extra coal consumed by the use of a hot water coil in his own furnace. His household, it might be stated, consisted of four persons. Over a period of thirty days he kept careful check on the coal used with the furnace coil in operation, and over a similar period the consumption with the coil disconnected. The results showed that in heating water with the coil 523 pounds of coal were required in excess of the amount required to heat his home with the coil out of the circuit. In the test bituminous coal costing $10.00 per ton was used, the monthly cost for heating the water by the coil being $2.61.

From other observations made by those studying the question, a fair

average consumption of fuel for heating water by a furnace coil is placed at 16 per cent. of the total consumption.

Taking this percentage, a home of, say, six rooms and burning eight tons of fuel during the seven heating months, a little over 1¼ tons of coal will be burned to heat the water only. During the remaining five months of the year it is common practice to use a gas heater for hot water requirements, and with a daily demand of 60 gallons a monthly bill of $2.50 for gas would not be out of the way.

This means that over the year hot water is costing about $18.50 for coal and $12.50 for gas, or a total of $31.00. Turning to electricity as a heating medium we find that with a flat rate system as now in use by the Hydro-Electric Power Commission of Ontario and a number of privately operated companies, a plentiful supply of hot water the year 'round can be had for much under this amount.

The cost of this erroneously termed 'velvet' supply of hot water from a furnace coil may be arrived at from another angle.

Let us assume a household of four persons using 60 gallons of hot water per day. In one month the hot water demand is 1,800 gallons, or 18,000 pounds. In order to raise the temperature of the water from 52° (incoming supply) to 160°, approximately 1,944,000 B.t.u.'s will be required (18,000 x 108). Taking anthracite with a heat value of 12,550 B.t.u's per pound, we find, to our chagrin, as firemen, that the normal householder is only obtaining about 45 per cent. of this heat, due to faulty firing, etc., or approximately 5,650 B.t.u's per pound of coal shoveled into the furnace. To supply the heat required by these 18,000 pounds of water per month (1,944,000 B.t.u's.) 344 pounds of coal are required (1,944,000 ÷ 5,650)—which is not so 'velvet'! With heat values of coke at 13,000 B.t.u's per pound; fuel oil at 19,000 B.t.u's per pound, and gas at 500 B.t.u's per cubic foot, and allowing for firing inefficiency, similar figures may be obtained.

From the foregoing it is apparent, therefore, that with the householder in a receptive mind for economies, as he is to-day, electric water heating can be shown to be not a luxury but an actual money-saver. In addition, the supply of hot water is automatic, constant, and what is most desired, really hot. As a writer in this magazine has stated, it is not electric hot water equipment that the salesman must sell, but hot water supply. It is hoped that the foregoing will be of some help in enabling him to better accomplish this.

* * * *

The Sanitary Age in commenting on Professor Steele's experiments, refers to a paper read by Edwin Newsome of Toronto, before a Convention of the Canadian and American Gas Association, held at Niagara Falls in 1919. It was entitled "House Furnace Efficiency With and Without Tank Heater Coils". Mr. Newsome's address contains useful information on this subject and is therefore repeated here.

TEXT OF E. NEWSOME'S ADDRESS

There seems to be a lot of people in this world who are ever on the lookout to get something for nothing. This

applies somehow to people who, as a rule, ought to know better.

If I came to any of you gentlemen and said, "Give me ten dollars, and I will show you in a second how it can be turned into $15, without, as a matter of fact, ever changing ownership," what would you think?

If I said to you gas men that although the B.t.u. value of gas sold by you was 500, I could get 600 B.t.u.'s out of it, what would you think of such a statement?

Very well, if I sold any of you a hot water boiler or furnace, say a Number 5 with a heating capacity of 835 square feet of radiation or 2,500 lineal feet of one-inch pipe, and then I told you that you could heat a 30-gallon range boiler from a coil or heater installed, and that heating capacity of the furnace was going to be cut down by 90 to 120 square feet, what would you say?

Gentlemen, these are some of the questions which should be discussed with every house owner or tenant in whose house a furnace is in use.

Some years ago the average heating engineer, steam or hot water fitter, or whatever you may call him, concluded that to fit a coil in a furnace, said coil to be connected to a range boiler, would enable the owner or occupant of the house to procure an almost unlimited supply of hot water for nothing, the average person swallowed hook and line, and to-day there are hundreds of thousands of coils and domestic heaters so installed in furnaces.

Personally, I believe these steamfitters thought so themselves. It was simply a case of not investigating and procuring proofs on the one hand, and partly the result of manufacturers of gas appliances not showing these steamfitters differently. These men know now and would prefer to sell gas appliances if they were taught how.

A number of boiler and furnace manufacturers, however, began to give the matter some serious study, and concluded that to install such coils meant adding a load to the furnace. To-day very few of these boiler manufacturers allow such a theory, or, for that matter, practice, to go unchallenged.

In quite a number of fitters' handbooks, published by boiler manufacturers, the attention of the reader is called to the fact that if a coil or heater of any kind is inserted in the fire box of a furnace, a deduction from the rating must be made equal to 3 square feet of radiation to every gallon of water heated.

Such being the case, if we assume that only thirty gallons of water is used in a day, or that a 30-gallon boiler is connected to a coil containing one square foot of heating surface, then the heat loss would be equal to 90 square feet of radiation.

It is estimated that most residences are of such size as to require a No. 4 boiler to heat the interior (the rating of such a size of boiler is about 650 square feet), and as a 30-gallon boiler is the average size installed, then the furnace capacity for heating purposes has been reduced by at least 90 square feet or equal to about 15 per cent.

But this is scarcely the whole loss incurred. Let us consider another authority on heating—William Hutton, in his book entitled "Hot Water

Supply and Kitchen Boiler Connections," writes as follows:

"Cast iron section suspended from the fire box crown and containing one square foot of surface is equal to 15 square feet of radiation.

"Cast iron sections in contact with fire, 1 square foot equals 50 square feet of radiation.

"Pipe coil, 1 square foot equals 20 square feet.

"Pipe coil, 1 square foot equals 35 square feet."

But, this same author goes on to say, "as the above readings are based on a flow of water to the radiators at 170 degrees F., and that is about the highest temperature maintained in hot water supply tanks, it may be calculated that for domestic use:

"1 square foot of cast iron surface in contact with the fire will heat 25 gallons per hour.

"1 square foot of iron coil suspended over the fire will heat 15 gallons per hour.

"1 square foot of iron coil about half in contact with the fire will heat 25 gallons per hour.

"1 square foot of brass pipe coil in close contact with fire will heat 30 to 35 gallons of water per hour."

While the above figures are only approximates, they are based upon actual observation, under every day conditions, and if such figures are anywhere near the mark it is easy to see that to secure such a large amount of hot water is bound to interfere as well as cut down the heat rating of a boiler.

The question of heat loss from range boilers, too, must be taken into consideration, and to prove that there is a big loss I will give you one case where my own gas bill averaged 25 per cent. less when I covered a range boiler with a good asbestos covering.

We lived in a house where all heating of water and cooking was done by gas. The only coal used was for the furnace, and, by the way, I had no domestic coil in the furnace. My monthly gas bill, previous to covering the range boiler, averaged $6.25 to $6.50 per month, winter and summer, for a family of nine in the house. After I covered the boiler the gas bill dropped to $4.75 and $5. The cost of gas per 1,000 was $1.20.

The loss of radiation from a range boiler, based upon regular heating surface, is approximately 17 square feet for a 30-gallon size, and this amount can be added to, when we consider that the average basement is cooler than any other portion of the house. Most of you know that range boilers are now as a rule placed in the basement.

I am not going to give you any names or addresses where coils or domestic water heaters have been taken out of furnaces, but I can assure you gentlemen, that during ten years' experience with the tools I have proved conclusively that a domestic coil in a fire box does lower the rating of a boiler or furnace, and, as editor of two trade journals during a period of eight years, I have had lots of experience all over Canada.

About four years ago a real estate agent connected with a trust company called me in to look at the heating systems installed in a number of houses owned by them which were hot water. These systems were well installed, and I learned that a competitive boiler manufacturer claimed

that their furnaces were a certain per cent. more powerful, etc. The houses had only been built about six months, and the tenant complained bitterly about the houses being cold. This was in January.

I measured up the houses, arrived at a heat loss, found that the heating specifications had been carried out to the letter. Each house contained 900 square feet of radiation (hot water). Each house had a 40-gallon range boiler, with a well-known gas water heater fitted to same, a double ring, or sectional domestic coil was also connected to each range boiler. I found also that after the furnaces and sizes of same had been decided upon, the glass surface had been increased by adding a sun room to the houses. These had to be heated from the same furnace, and this meant that the furnaces were approximately 15 per cent. overloaded.

I at once advised that before changing the furnaces it would be well to take out the domestic coils and see what happened. The coils were taken out, and from that time on the furnaces gave splendid service, with an actual reduction in the coal consumption.

As a matter of fact, I could go on citing case after case where the domestic coil has resulted in as high a heat loss as 20 per cent. of a furnace. My opinion is that where a house requires, say, 600 feet of hot water radiation, a 12-inch coil will cut down the furnace rating by at the least 120 square feet. I know of scores of cases where such has been proved.

I am not, however, condemning the use of a domestic coil in furnaces, but I do object to heating men and those interested in selling coils allowing the public to be deceived.

If the public are told that to install a domestic coil in a furnace means a loss instead of a gain, then I have no fault to find with the domestic coils. And, on the other hand, if where a 600-foot boiler is needed with, say, 500 sq. feet of radiation installed to heat a house, and a 30-gallon boiler is to be heated by, say, a 12-inch cast iron coil, then the customer, or builder, should be told that the furnace is being overloaded.

Just imagine, at this present moment, the cost of a hot water heating system averaging \$1.75 to \$2 per square foot of heating surface, including boiler, and say the job requires 500 feet of radiation, and the boiler is a 600-foot one. The total cost of such a job would be around \$875 to \$1,000, and we will assume that a domestic coil is installed with a 30-gallon range boiler. This latter cuts down the boiler power by about 120 square feet, or even based upon figures taken from a number of Fitters' Companions, say, 90 square feet is from \$157.50 to \$180.

How foolish it is to install a domestic coil in the face of such figures, and particularly when such a domestic hot water supply is only available during the winter season.

I suppose most of you gentlemen know why coils do reduce the heating capacity of a boiler. The cold water passing through the coil cools the unconsumed gases, and interferes with proper combustion.

Such a coil also prevents the fire from reaching the first section of the heating surface of a furnace.

The same arguments apply where

warm air furnaces are in use. Have any of you gentlemen observed how very dirty a set of hot water coils get when such coils are used for combination warm air and hot water heating systems? You will find that not only do the coils get caked and coated with a pitchy coating, but the warm air radiator and smoke ways or fire travels will be found to be heavily coated with soot, etc., and, other than asbestos, I do not know of a more effective heat insulator than soot. These soots are in reality unconsumed fuel, so that it will be clearly seen that any apparatus installed in the firebox of a furnace which interferes with the proper combustion of fuel is a detriment to any heating system, whether for domestic or commercial heating apparatus.

Finding of Lost Balloonists

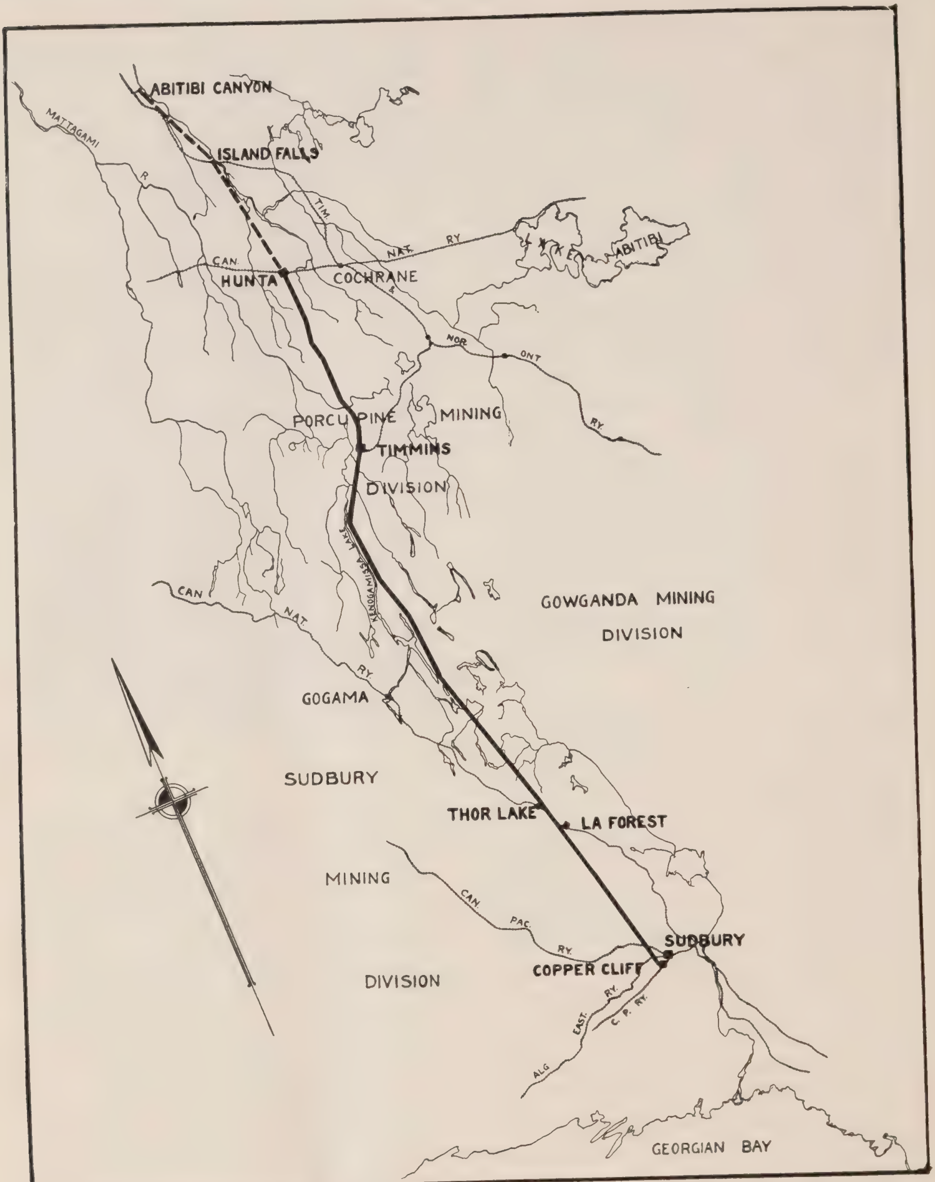
On Monday, September 11th, 1933, the news was broadcast that Pilot Ward T. Van Orman and his aide, Frank Trotter, who had been missing for over a week with their balloon, Goodyear IX, had been found by a Hydro patrolman in the Sudbury district of Northern Ontario.

About 3.30 p.m. (E.S.T.), on the 10th, the operator at Copper Cliff discovered trouble on the Abitibi telephone line north of LaForest. Early the next morning James Barrett, Hydro Patrolman, located at LaForest, went out and at tower 730, about thirteen miles from his starting point, found a telephone pole had been cut down, breaking the wire. He also found a note attached to the pole. It read—

"This telephone pole was cut September 10th by U.S. Goodyear balloon team of W. T. Van Orman and Frank Trotter in the hope that repairmen would aid us in getting to civilization from here. We will continue south along the high voltage line. Please come after us. We have a gun and some food, but are both sick, evidently from ptomaine poisoning. Fire your gun three times and we will answer. Please hurry. Signed Frank Trotter."

Patrolman James Barrett.

Following these instructions Barrett turned back and at tower 738, about a mile and a half from where he found the note, were Van Orman and Trotter in a line patrol camp. Barrett gave the balloonists his food supply and after making a temporary



Map showing location of Abitibi-Copper Cliff transmission line and area in which the balloonists landed.

repair to the telephone line brought them to Thor Lake railway station, where they were placed on a ballast train and taken to Capreol and from there by motor car to Sudbury.

Briefly, that is the story of the rescue, a duty that fell to the lot of a Hydro patrolman in the performance of his ordinary work.

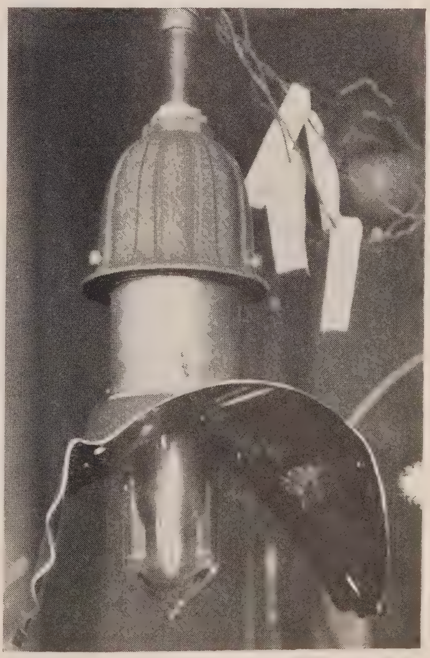
The balloonists were the crew of one

of the balloons that had set out on the evening of Saturday, September 2nd, on the James Gordon Bennett international balloon race from Chicago. By Sunday evening they had travelled about 500 miles to a point near Thor Lake, about 55 miles north of Sudbury, where they were forced down by a storm. Here they improvised a camp from the wreckage of the balloon and stayed until Wednesday morning. They then started for the railway, which they estimated to be about 20 miles distant. The country is very rough—trees, cliffs, valleys, rocks, boulders, muskeg—and by Saturday morning, three days later, they estimated they had progressed but about 12 miles from the balloon. On Sunday they had reached the transmission right-of-way. After following the right-of-way for about 3½ miles they cut down the telephone pole and then proceeded onward until they came to the patrol camp, where they were able to make themselves comfortable for the night and where Patrolman Barrett found them the next day.

Highway Illumination by Sodium Vapor Lamps

(*Note from the Illumination Laboratory, Hydro-Electric Power Commission of Ontario.*

FOR the past few years those interested in lighting have followed with increasing interest the efforts of scientists engaged in the problem of producing practical high-efficiency light sources from luminous gases. This work has reached a stage where experimental applications of the results are being made. The nearest installation is on a section of the Ballston Road near Schenectady, which is illuminated by sodium vapor lamps. Following is a brief description of the installation and the impressions gathered from observations of it.



Sodium vapor street lighting unit, not lighted.

Location—Ballston Road, Town of Niskayuna, Schenectady County, from the intersection with the Albany-Schenectady Highway, extending north for 2270 feet.

Types of Lamp—Hot cathode sodium-vapor, manufactured by G.E.

Ballston Road, Schenectady, N.Y., showing experimental installation of sodium vapor street lighting units.

Vapor Lamp Co., collaborating with the G.E. Research Laboratory. Rated 2 v. a.c., 10 amp. filament; 5 amp. d.c., approximately 13 volts arc; no lumen rating assigned. Initially the tubes average 3,500 lumens output; 4000-5000 lumens output is expected ultimately. About 1,000 hours average life is expected from the present lamps but this will ultimately be increased. Average wattage of present lamps is 82 including heater. Lumens per watt 45-50.

Types of Fixtures—Special design consisting of cast iron hood containing filament heating transformer and tube socket, chronium plated Asyradial wave shading reflector, and double wall evacuated flask which encloses the sodium tube.

Mounting—Fixtures are suspended on mast arms 3 ft., over edge of roadway, 23 ft. from roadway to light centre.

Spacing—Arranged for 125 ft. staggered spacing or 250 ft. staggered spacing by switching. 22 units are provided, 18 for the 125 ft. spacing and 9 for the 250 ft. spacing. 500 ft. spacing on one side can also be obtained using 5 lamps.

Power Supply—All 22 filament heating transformers are connected in multiple on a 120 volt supply through a tapped auto-transformer for adjustment. D.C. arc current is supplied to 18 (or 9, as the case may be) lamps in series from a special pole mounted constant current Thyratron rectifier operating from 2300 v. a.c. primary. A control station near the base of the pole provides for switching and arc current adjustment. The power factor of a circuit of sodium lamps is expected to be as high as a similar circuit of tungsten lamps.

Operation—A photo-electric controller turns on the Thyratron and Sodium tube filaments at a daylight intensity of about 15 foot candles. After a 5-minute heating period, a definite time relay applies the d.c.

The lamps are distinctly red on starting, due to presence of neon gas, the neon arc providing heat to vaporize the metallic sodium. The tubes gradually turn yellow as sodium vapor forms. The tubes reach full brilliancy in about 30 minutes, at which time the light is almost entirely yellow. The burning is stable and no "flickering" etc., can be noticed.

At a daylight intensity of about 20 foot candles, the photo electric controller switches off the lights. The lights can also be turned on and off manually.

The electrical system used is more complicated than would be necessary were it not for the experimental purposes of this installation. The present types of lamps probably could be used on 3 wires. Ultimately, it may be possible to see only 2 wires and even to operate successfully on a.c. power. The system used here is calculated to afford favourable conditions for determining the practicability of lighting with Sodium tubes and to indicate practical considerations which will influence the future development.

Illumination—At 4000 lumens per lamp, or 32 lumens per linear foot of roadway, the resultant average illumination is calculated to be .36 hor. f.c. on the road surface.

The color of the light is brownish yellow which at first is unpleasant, the highway appears dull and one's first impression is disappointing. However, when one becomes accustomed to the light its merits may be observed.

As will be noted in the description of the installation the lamps may be grouped in three ways so as to produce different distributions of illumination. During the time when it was observed by the writer eighteen of the twenty-two lamps were in operation. This combination produces the best distribution and highest intensity of illumination. This illumination was considerably better in distribution than any ordinary installation of tungsten lamps for highway lighting. Consequently the merits of this lighting are partly due to the excellent distribution as a correspondingly good distribution of tungsten light would also be much

Ballston Road, lighted by sodium vapor lamps, 125 ft. staggered spacing.

better than ordinary highway lighting.

However, the sodium light in itself has some distinctive features the most noticeable of which is the reduced intensity of glare. The sodium lamps appear less bright in comparison to the road brightness than do tungsten lamps. The effect of this is that the seeing conditions for a given intensity of illumination are better than is the case where more glare exists with the same illumination intensity.

The claim with respect to similar installations in Europe that night driving without headlights is possible seems to be fairly well substantiated by this installation in America.

In the absence of approaching headlights a man crossing the road at a considerable distance, possibly 1,000 ft. or more, was easily noticed. The short stretch of highway illuminated by the sodium lamps was hardly sufficient for a thorough test of driving without headlights, nevertheless a number of cars using the highway were driven at fair driving speeds, probably 40-45 miles per hour with only the small side lamp in operation.

The color of sodium light is almost entirely of one color, yellow, and the distortion of colors is obviously excessive. However, this is not of much importance for the purpose under consideration.

This installation is entirely in the nature of an experiment. Its full intensity, upon which the foregoing comments are based is about three times that stated in the street lighting code of the Illuminating Engineering Society for highway illumination. The high efficiency of sodium light will provide one means of hastening the accomplishment of what is recognized as the only reliable means of reducing the dangers of night driving, that of illuminating the highways so that strong headlights will be unnecessary.

The manufacturers of these lamps feel that the life of the lamps is short in view of the high cost of the equipment and efforts are being made to increase the life and also to make larger sizes. At the present time there is no commercial demand for these lamps and their cost is naturally high. No serious difficulty is anticipated in making the lamps on a factory production basis and it is safe to assume that as soon as the engineering requirements of highway lighting with these lamps are settled they will become available for extended use.

In conclusion, the two outstanding features of sodium lamps for highway lighting are high efficiency and reduced glare. Whether the latter is a property of sodium light or a characteristic of the more extended area of light source as compared to the concentrated tungsten filament can only be proved by direct comparisons.

Acknowledgement is made of the courtesy of the General Electric Co., in furnishing the information regarding the lamps and the installation and the photographs with which this article is illustrated.

Uhl River Hydro-Electric Development, Punjab, India

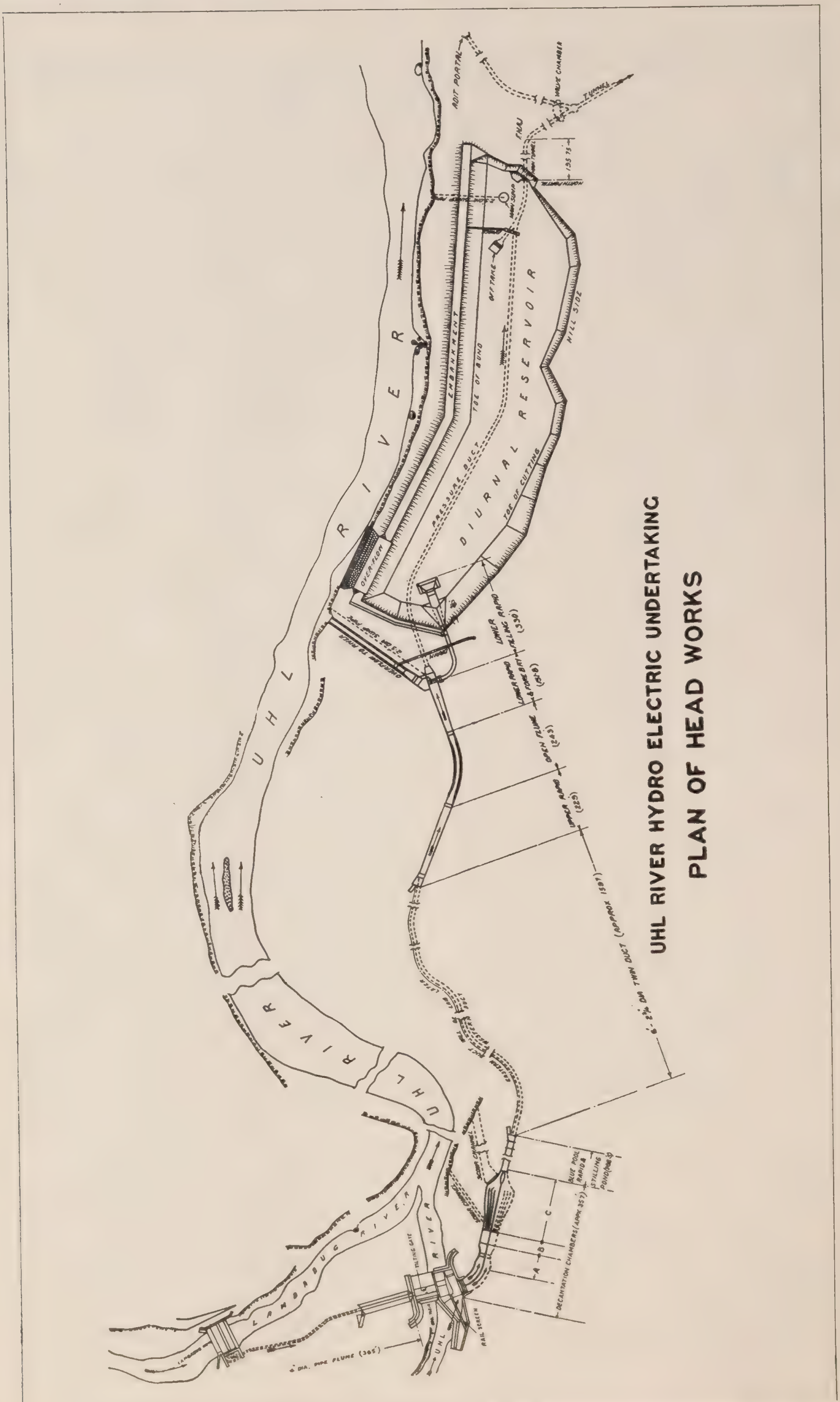
On March 10, 1933, His Excellency the Viceroy of India opened the first stage of the largest hydro-electric scheme so far undertaken by the Government of India. The Uhl River development in the Punjab is based on the fact that the Uhl and Rana Rivers flow parallel with each other at a distance of about six miles, but at a difference of elevation of about 2,000 ft., the two being separated by a spur of the Dhauladhar range of the Himalayan Mountains. Water from the Uhl is passed through a tunnel under this ridge and discharged into the Rana. The development is to provide electricity for general use in an area where there is but little coal.

It was the desire on the part of the Punjab to make power from local natural resources available for industrial development and general use at a minimum cost that lead to the undertaking. The Hydro-Electric Power Commission originated from a similar desire on the part of the people of Ontario, and no doubt the study of the Commission and its work by the Punjab officials and engineers had an influence in formulating this scheme for development and distribution of hydro-electric power.

The Uhl River is a glacial stream, the water being heavily laden with silt. The water taken from the river passes through a series of decantation chambers where the silt drops out. The decantation chambers are kept clear by sluices below sloping vanes in the bed of the chambers. The water then passes through ducts and flumes a distance of about 2,800 ft. into a reservoir of some 7,000,000 cu. ft. capacity. This reservoir is necessary to equalize the flow of water during a 24-hour period as provided by the river. Fig. 1 shows a plan of this section of the development.

From the reservoir the water passes through a tunnel, 9 ft. 3 ins., in diameter, nearly 3 miles long under the mountain ridge. This tunnel was lined with concrete, steel reinforced and surface gunited; its length from portal to portal is 15,308 ft. Fig. 2 shows the power house as completed for the present development and two steel penstocks from the tunnel portal down the side of the mountain, each being approximately 2,300 ft. long. Fig. 3 is an interior view of the power house during construction. The static head at the plant is 1,800 ft. and the generating capacity now installed is 48,000 kw. The transmission system consists of 224 miles of 132,000 volt, 140 miles of 66,000 volt, 36 miles of 33,000 volt and 81 miles of 11,000 volt lines. There is a total of 22 substations, 6 of which step down from 132,000 volts, 8 from 66,000 volts and 8 from 33,000 or 11,000 volts.

Without going into the details of construction of the various works, some unusual features may be referred to. It was recognized by the Punjab Government that the industrial progress of the state was hampered for the want of cheap power.



UHL RIVER HYDRO ELECTRIC UNDERTAKING
PLAN OF HEAD WORKS

Fig. 1

Fig. 2—View showing power house and outdoor transformer and switching structure, also penstocks and haulage way down the side of the mountain.

Electric light and power have been supplied to the towns and factories of North West India from small plants, municipal or private, which produce their current at a cost varying from 1½ to 4 cents per unit. This cost was considered a high figure, hampering the development of industry. The production cost, according to the first estimate for the Uhl River scheme, was to be ½ cent per unit on the high tension line and slightly over 1 cent as delivered to the local plant. Rates enforced are not quoted, but at the opening ceremony it was stated by the Honourable Dr. Gokul Chand Narang, Minister of the local Self-government—"To make this energy available to all . . . elaborate tariffs have been devised to suit the circumstances of each consumer. These tariffs are so designed that the cost decreases with the increase in the bulk of the energy purchased by the consumer." The meanest hovel in the suburbs of Srinagar, the capital of Kashmir, uses electric light, suspending the wires and bulbs precariously from crumbling beams or the branch of a neighboring tree, and the Punjabi peasant is not less appreciative of such comforts if they are placed cheaply within his reach.

The development is located about 100 miles above railhead in the north of the Punjab and was begun in February, 1926. The spot chosen for the headworks was in an imperfectly

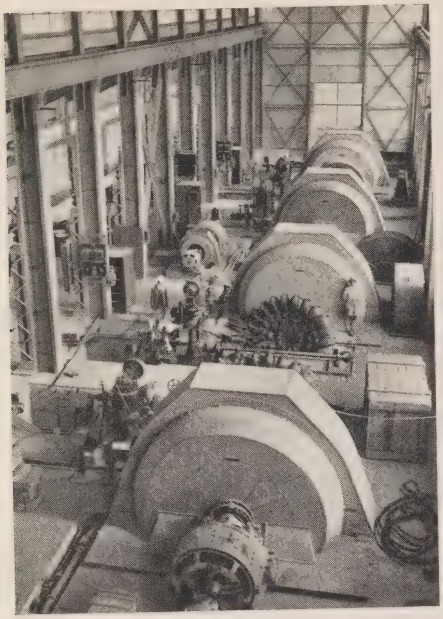


Fig. 3—Interior of power house.

developed and rugged country, inaccessible by roads. It was therefore necessary to build a haulage way from the Southern side of the range near the power house site which is at a level of 4,000 ft. to a level of 8,000 ft. thence round the crest and down again to 6,000 ft. on the Northern slope. These works were carried out with considerable difficulty amid the heavy snow of winter and the torrential rains of the hot season, and occupied 33 months in completion.

The tunnel passes 3,000 ft. below the crest of the range making it impossible for an engineer when preparing an estimate to foresee the nature of the rock or other material likely to be encountered. A thick stratum of slimy clay and another of crumbling stone were encountered at a considerable depth making the progress at these points disappointingly slow.

To provide this undertaking the Punjab Government has had to raise funds to the extent of 6¼ crores of rupees ($20,250,000); besides which, 40 lakhs ($1,296,000) will have to be raised for building distribution lines.

By adding another duct between the decantation chambers and the diurnal reservoir of the headworks and two more steel penstocks with power house generating equipment, the capacity of this development can be doubled at a proportionately small extra expense. Within the next three miles below the power house there is a further drop of 1,200 feet where it is possible by the construction of a flume and pipe line to use the water for the generation of additional power and bring the total up to about 120,000 kilowatts.

We are indebted to D. W. David, Kangra, Punjab, India, a member of the engineering staff during construction, for the photographic illustrations used in this description and a copy of a brochure containing the headworks diagram and statistical information. Other data are from articles published in "*Engineering*."

Construction Features of the Chats Falls Development

By H. L. Trotter, M.E.I.C., Resident Engineer, Chats Falls Engineering Board, Montreal, Que.
and
James Dick, A.M.E.I.C., Chief Engineer, Morrow and Beatty Limited, Peterborough, Ont.

(*Paper presented at the General Professional Meeting of the Engineering Institute of Canada, at Ottawa, Ont., February 8th, 1933.*)

THE work on the power development at Chats Falls presents a number of interesting features of construction, such as the placing of concrete in structures having a continuous length of 13,500 feet; the construction of an earth dam 4,300 feet long; the unwatering of a stream which has a large variation in flow throughout the year, and the regulating of this discharge so that there would be no damage to the work as it proceeded.

The manner in which the various parts of the construction were performed may be of interest, and, in presenting these, it has been decided to deal with them in the order in which they occurred in the course of the work.

The accompanying Fig. 1 shows the general plan of the site and the layout of the structures as built.

Operations commenced in the early part of October, 1929, with the clearing of the site, which was heavily wooded throughout; the erection of camps, and the construction of a spur from the Canadian National Railway to provide access to the work.

Living quarters were provided on the site for the employees, as the local facilities in this connection were inadequate to accommodate the large number of men ultimately engaged on the construction.

The buildings erected for camps and other temporary uses were of the usual wooden construction except that they were sheathed inside and outside with three-eighths inch plaster board, a type of construction which effected an appreciable saving in the cost of labour and material.

The complete camp establishment was in two sites, both identical in plan, and these provided sleeping and dining quarters for fourteen hundred men. Each camp comprised a main dining hall and two buildings, each divided into ten sections, for sleeping quarters. Separate accommodation was provided for staff, foremen and mechanics.

The railway spur was built from the main line of the Canadian National Railway, and was used to transport construction plant, materials and permanent equipment to the central part of the site. The first mile of the track now forms part of the permanent railway to the power house and the construction of this part involved building bridges across two channels of the river. These structures are standard deck plate

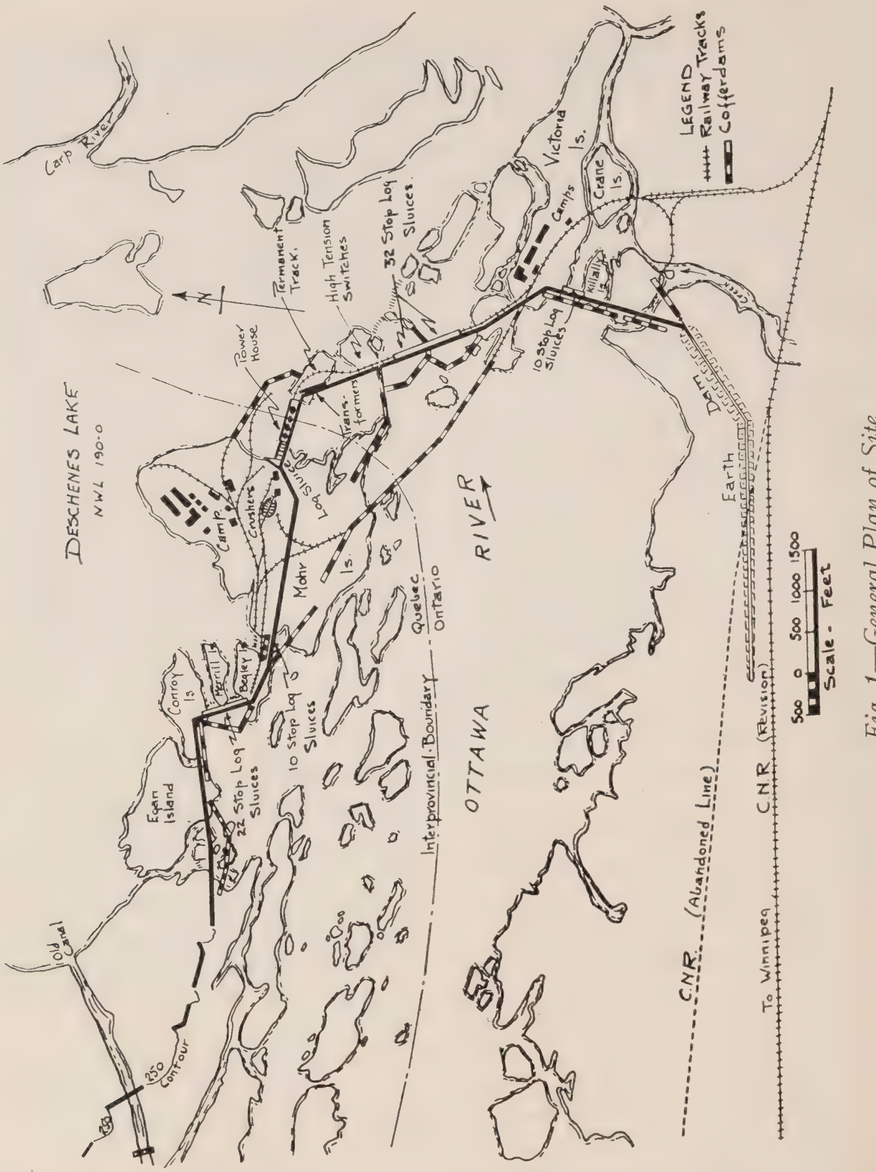


Fig. 1—General Plan of Site.

girders, designed for Cooper E 40 loading, and are carried on concrete abutments.

To reach the central part of the work, at Mohr Island, the temporary part of the railway was carried across the main channel of the river on a standard trestle deck supported by cofferdams, a description of which is given further on.

The total length of standard gauge tracks laid was 6½miles, ofw hich 1½ miles remained as the permanent railway to the power house.

Cofferdams

The number of channels through which the river passed entailed a large quantity of cofferdam work; but that feature of the topography was of assistance in the diversion of the flow.

Before any unwatering was started a careful study was made as to the elevation to which the river, with certain of these channels closed, would rise at the time of maximum flow in order to determine the height to which the cofferdams should be carried. Adequate provision was made in the permanent structures for discharge by the introduction of seventy-four sluices, arranged in four sections of stop log dams.

Until one of these sections was completed, through which the flow could be permanently passed, cofferdams were placed only in one or two channels at one time.

The first cofferdam constructed, known as No. 1 cofferdam, crossed the widest channel, and, carrying the track to Mohr Island, had to serve as a railway bridge until the completion of the work. This condition, in conjunction with the fact that it crossed the channel of greatest discharge, and enclosed a sluiceway section of dam, made it necessary to provide means of passing the flow after these sluiceways were built and while other parts of the dam were being unwatered. Construction was of the usual rock-filled timber crib type closely sheathed on the up stream face. It was provided with fifty-four sluiceways 16 feet wide separated by piers of the same width. Stop logs were provided so that the area below could be unwatered during the construction of the permanent dam across that part of the river.

All other cofferdams were built of square timber, generally 10 by 10, in sections of about 20 feet in length. Rock pockets were about 6 feet by 8 feet in plan with a smaller pocket left empty of rock in each crib, for loading with explosive, wherever it was the intention ultimately to remove the cofferdam with dynamite.

Sheathing consisted of one thickness of two-inch plank with a second covering of one-inch. Divers were used to place the sheathing under water, and carefully scribe it to the bottom. The usual manually operated air pumps for the divers were replaced by air service from the compressed air lines placed throughout the site and air was supplied through reducing pressure valves. The complete installation for each crew comprised high and low pressure receivers so that there was sufficient air for the diver until he emerged in case of failure in the main service lines.

The power house site, and that part of the dam lying immediately to the south of it, were unwatered by the construction of a cofferdam around the tailrace and one between Mohr and Aumond Islands. The latter was so placed that it enclosed the forebay and the part of the dam mentioned without interfering with the regulation through No. 1 cofferdam sluices.

The tailrace cofferdam was on a boulder foundation overlying the solid rock to a depth of 3 to 8 feet.

The maximum head was 30 feet, and a water tight job was secured by placing a substantial toe fill, of mixed

clay and gravel, along the full length of this dam to above high water level.

All unwatering structures above the dams were on solid rock so that very little toe fill was required.

Concrete, however, was used as a seal at the foot of the sheathing wherever it was above water level at the time of construction.

The construction of the permanent work across the main channel between Aumond and Victoria Islands was done in two stages inside small cofferdams which diverted any leakage or discharge from the sluiceway cofferdam above.

Concrete was started on June 19, 1930, and was confined to dry land operations until after high water, which, being late that year, reached a peak of 118,000 c.f.s. about the middle of July. With the exception of certain gaps left for passage of temporary tracks, all concrete in the dams, between Victoria Island and Conroy Island, was completed by December 19, 1930, a distance of 8,000 feet.

The completion during this time of the thirty-two sluices in the main channel permitted the closing of certain channels on the Quebec side, where other sluiceway sections are located. Before the end of the 1930 season these sections were completed making available in all sixty-four permanent sluices 18 feet in width for handling the next season's flood.

Rock Excavation

The foundations of all concrete structures are on solid rock. The original surface was very rugged and considerably eroded in the stream bed and on the islands where much higher water conditions in the past had created fissures and pot holes, some of the latter having a depth of six feet. The preparation of foundations required the removal of 270,000 cubic yards of rock of which quantity 195,000 cubic yards was taken from the power house site and forebay, and the remaining 75,000 cubic yards from the dam site and other parts of the work.

The excavation at the power house was taken out in two stages. The headworks site, or upper level, was completed first. This had to be removed by sinking, in an open cut, for depths of from 12 to 25 feet, to a grade which sloped down stream from the line of the structure. The draught tube section was open face excavation and was worked from tailrace grade, 40 feet below the upper level.

Drilling was done with pneumatic hand drills using hollow hexagon steel one inch in diameter. The depth of each lift varied but did not exceed fourteen feet. The drilling was closely spaced at all abrupt changes of section, particularly at the outlines of the spaces required for the draught tubes, so that excavation was reduced to the minimum required. Compressed air was supplied by four compressors installed in a central power plant. In addition there were three portable gasoline operated compressors used as boosters to the lines at distant parts of the work, particularly on the dam excavation.

Standard gauge tracks were laid to reach all parts of the power house excavation, and the rock was removed in six cubic yard side dump cars. The loading was done by three gasoline operated shovels, mounted on

caterpillar traction, each with a dipper capacity of one and one-quarter cubic yards. The rock is a granite gneiss and most of the quantity excavated was used for concrete aggregate, the selected material being delivered direct to the crushers or to a storage pile. Rejected rock was placed either in the tailrace cofferdam or in a waste pile from which it was later taken for use as rip rap and grading purposes.

Rock excavated from the dam foundations was wasted, or, wherever necessary, used in cofferdams. The removal was done in wheelbarrows and the rock cast to each side of the excavation. In some cases small derricks of two-ton capacity were used where the cut was deep. The foundations were grouted as the work proceeded. The grout holes were, on an average, 20 feet deep and were spaced 20 feet apart on a line from three to six feet from the up stream face of the dam.

Grouting operations, disclosing faulty rock, determined the depth to which the excavation had to be carried. This depth throughout the length of all dams averaged five feet.

Concrete

All concrete was mixed at a central plant located near the power house and about the centre of the development. The equipment installed for concrete production comprised rock crushers, mixers, batchers and belt conveyors for handling sand, stone and cement. All this equipment as well as other stationary power equipment was electrically operated.

Fig. 2 shows the arrangement of the concrete plant.

The crushing plant consisted of two crushers, the first being a 36-inch by 48-inch jaw crusher rated to give a daily production of 1,900 cubic yards of 8-inch stone, and a cone crusher of like capacity. A 36-inch belt conveyor, operating on a slope of seventeen degrees, carried the stone from the primary to the secondary crusher where it passed over a fine "grizzly" before entering the hopper. The fines resulting from the first crushing were thus removed and by-passed on a 12-inch belt conveyor to a waste pile.

The finished stone was carried from beneath the cone crusher by a 24-inch belt conveyor up a slope of nineteen degrees to the distributor above the storage pile. As the stone left this belt it passed over a vibratory screen which removed the dust caused by the secondary crushing. The removal of dust and other fine material from the crushed stone was found to be advisable because they had a tendency to assemble in the stock pile, and, passing with the stone to the mixers, would cause sudden increases of fine aggregate in the concrete. To provide adequate storage the stone was distributed at the top of the pile by the use of a shuttle conveyor, and the quantity was maintained at about 8,000 cubic yards. The stone was forwarded, from beneath the pile, to the bin above the mixing plant on a 24-inch belt conveyor which operated through a timber tunnel, 6 feet by 6 feet in section, placed underneath the full length of the storage.

This conveyor received the stone at a number of places through openings in the tunnel roof and the delivery to the belt was controlled by duplex gates.

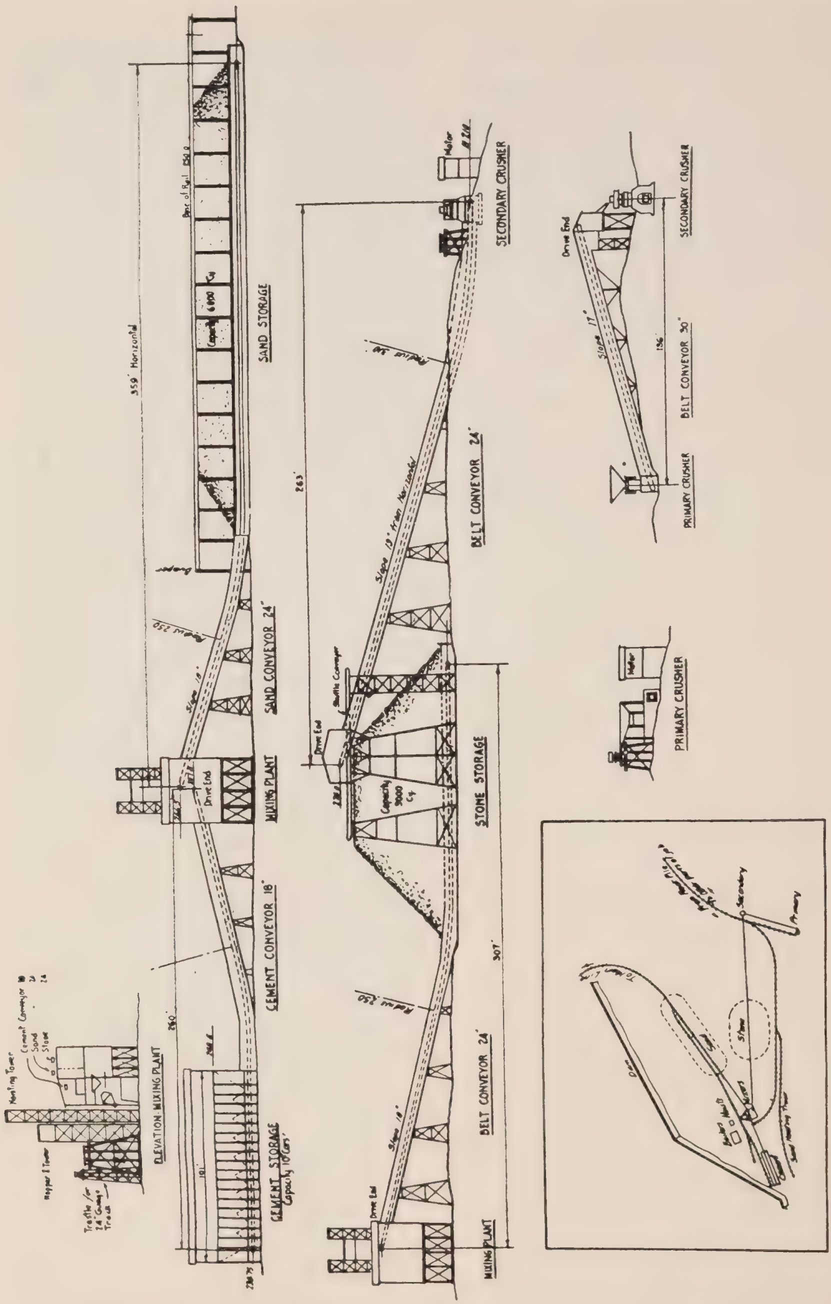


Fig. 2—Arrangement of Concrete Plant

The handling of the sand to the mixing plant was done in the same manner as the stone, using equipment of the same size and type. The sand was obtained from a deposit about 40 miles from the power site, and was

shipped to the work in bottom dump gondola cars of 40 cubic yard capacity. Loading at the pit was done by a crawler crane equipped with a 1¼-cubic yard clam shell bucket. With this type of equipment it was possible to make a selection of the material. It was not necessary to create a large storage of sand at the job because the shipments were regulated to suit the demand. The unloading track was carried on a trestle placed over the conveyor tunnel and the cars were unloaded directly into the storage.

Bulk cement was used and was stored in a timber bin of ten-car capacity. This bin was divided into a series of hopper bottom pockets and at the lower end of each of these was a slide gate through which the cement was passed to an 18-inch belt conveyor for delivery to the batchers in the mixing plant.

The standard box cars in which the cement was shipped were unloaded by a power operated scraper manually directed.

No trouble was experienced by cement sticking or arching in the storage hoppers, nor was there any leakage at the slide gates, as these were effectively sealed with rubber packing. A small air operated vibrator was, however, placed on the side of each cement weighing batcher to assure that these emptied completely for each batch.

The mixing plant consisted of two 2-cubic yard tilting mixers. The sand and stone stored in a bin above the charging floor were delivered to the mixer hoppers, by gravity, through short chutes controlled by lift gates.

All materials and water were weighed; and the mixing time was set at two full minutes in the mixing drum.

The establishing of a central concrete mixing plant was necessary for economy of production, but it entailed the transportation of concrete to the forms of the dam for distances which reached a maximum of nearly two miles.

Light railway equipment was used for the movement of concrete and the tracks were laid throughout the length of the dam and power house on a light wooden trestle placed on the upstream side of the structures, with the base of rail slightly above the level of the top of the forms. Concrete was transported in one yard, V-shaped, side dump cars, of 24-inch gauge, hauled in trains of eight to ten cars by a gasoline locomotive. These trains operated each way from the mixing plant as the formwork proceeded. To permit the work to proceed at a number of places at one time, the concrete was also transported in standard gauge 6-yard side dump cars from the mixing plant to two distributing points, one near the south end of the work and the other some distance to the west. A large hopper was placed at each of these distributing points and from these the concrete was hoisted to above the level of the dam, and taken away in the small equipment on the trestle which paralleled the dam.

The location of the light railway trestles permitted placing the concrete directly into the forms, and the hoppers through which it passed were fitted with flexible metal spouts, made up of detachable tapered sections, to facilitate the distribution.

All concrete was placed in this manner except the mass surrounding the draught tubes and scroll cases.

This mass concrete was placed by dumping from the cars on the trestle into inclined shutes, having a slope of 5 in 12.

The concrete passed down the chutes by gravity to hoppers leading to vertical flexible spouts, and through these it was conveyed to its required location in the forms.

Concrete placed in the dams and headworks was done continuously from rock foundations to the finished level without horizontal joints, thus eliminating leakage in dams and breastwalls. Gravity dams were built in sections 40 feet in length. Stop log dams and sluice gate dams were formed in three operations; first the aprons were placed, leaving the pier section out down to the rock; then the piers were formed, after which the decks were placed. Construction of the power house headworks was carried out in a similar manner, except that each pier with curtain wall, intermediate wall and breast wall extending to the centre of the span on either side was built as a unit, thus making a vertical construction joint at the centre of each span of the intake passages.

The power house substructure may be divided into three sections; the headworks, the part surrounding the draught tube and scroll case, and the extension to the draught tube with tailrace piers lying outside the line of the power house proper. These main divisions are indicated by vertical joints which are continuous for the full length of the structure. The concrete in the latter two divisions mentioned was placed continuously between horizontal construction joints as shown in Fig. 3.

In the power house substructure the initial operation was that of placing a concrete base to receive the draught tube form of each unit. The piers and walls separating the units outside the down stream line of the building were then built, closely followed by the slab above, which was bulkheaded at the centre of the piers separating the units. The concrete surrounding the draught tube proper was then placed, and stopped about nine feet below the level of the floor of the scroll case to permit of placing the draught tube liner and speed ring anchorages.

This section was also bulkheaded midway between centre line of units. In the next operation the concrete was carried to the scroll case floor level and the outline of this mass conformed neatly to the plan of the scroll case.

After the speed ring of the turbine was installed the forms with the pit liner were placed and the concrete was completed to the generator floor level. The construction joints of this section are at the centre line of units.

In the superstructure of the power house, which has a structural steel frame, the roof forms were carried on the trusses and were the first to receive concrete.

Using the roof slab as a runway the wall forms were then filled. In order to prevent cracks developing in the walls, from temperature changes, the pilasters formed about the main columns were concreted first up to the level of the top of the windows, after which the panels surrounding the windows were placed. The wall

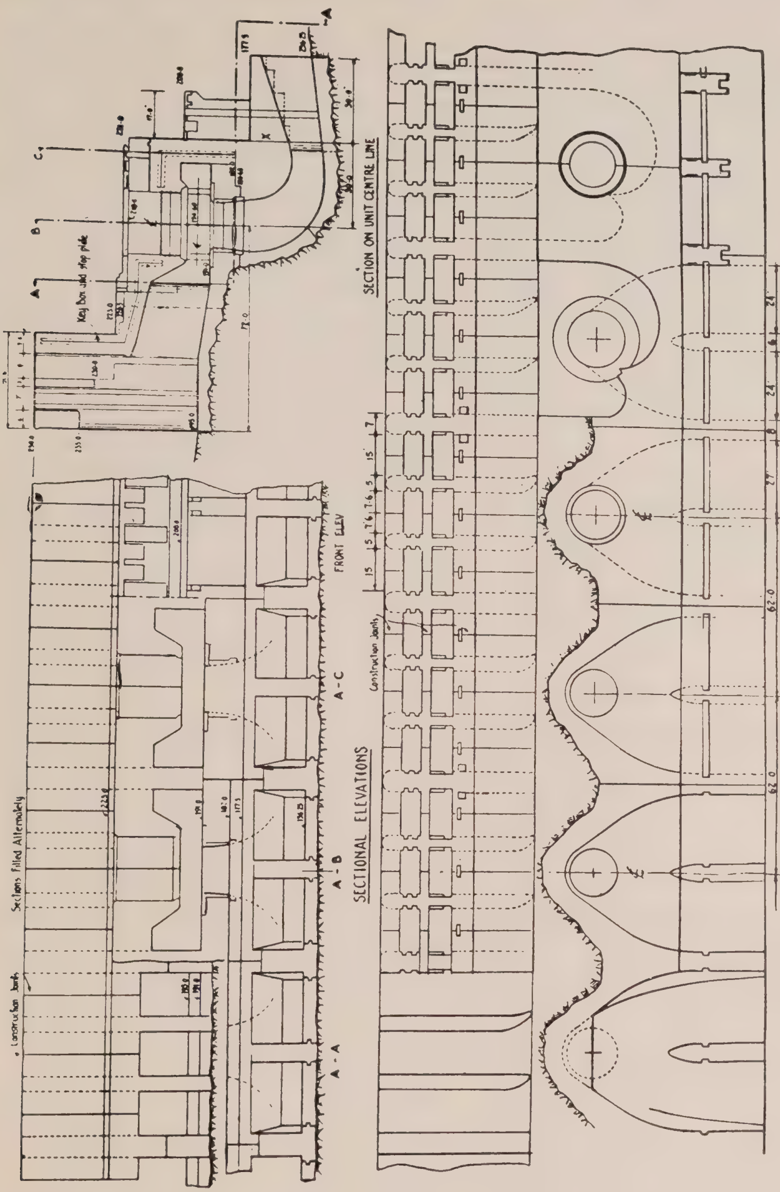


Fig. 3

NOTE:—*All construction joints are provided with key boxes and, at sections under hydrostatic pressure, with stop plates. Joint X has coating of emulsified asphalt.*

between the top of the windows and the roof was then placed with expansion joints at the same points as those provided in the steelwork, i.e., 62-foot centres.

To prevent leakage at all horizontal and vertical construction joints in the dams and power house substructure the adjoining sections were keyed together, and, on the gravity dams, the vertical joints were given a 3/16-inch coat of emulsified asphalt, applied with a trowel and left to set, before the adjoining concrete was

placed. No asphalt was used on such surfaces in the power house, but, to prevent leakage, a steel plate 3/16-inch thick and 14 inches wide, coated with asphalt, and having end connections lapped and welded, was placed in one of the checks or keys, 7 inches into the concrete on each side.

The total quantity of concrete placed was 240,700 cubic yards and 105,000 cubic yards of this was placed in the winter. To protect this concrete from frost the sand and water were heated before reaching the mixers. The method used to heat the sand was by fitting the cars, in which it was delivered, with a system of pipes so arranged that steam could be exhausted into the body of sand for some time before the cars were unloaded.

The concrete was protected during the placing and setting by completely closing in the forms with tarpaulins carried on suitable timber supports. The temperature inside this housing was maintained well above freezing by using a number of fan heaters equipped with steam coils.

The placing of concrete continuously from foundation to finished level made it necessary to have forms of rigid construction and securely braced to withstand the pressure induced by this operation.

No radical changes were made in form design other than to increase the size of the bracing. The usual 2-inch by 4-inch studding with 1-inch sheathing was used throughout for wall construction except on the gravity dams, where forms were built in panels and used repeatedly. Both of these types of form were braced horizontally by 6-inch by 6-inch walers placed 24 inches apart and over these 6-inch by 8-inch verticals were placed at 6-foot centres. The form walls were held in place by ½-inch rods threaded into clamps, fastened to the bracing on each side of the structure, and separators were placed inside the forms and removed as concrete work proceeded.

The curved portions of the draught tubes and scroll cases required forms of intricate construction and these were built in the carpenter shop. Each unit was made in two sections, split on the vertical centre line in the case of the draught tube and on radial lines in the scroll case form. These were made as light as possible for handling and additional internal bracing was necessary after they were placed and connected to the adjoining form-work.

Equipment Installation

The standard gauge tracks laid to reach all important parts of the work provided economical facilities for handling the permanent equipment to the various sites on which it was to be installed.

The aggregate weight of this equipment was 9,600 tons and the heaviest single shipments were the 220-kv. transformers which weighed 114 tons. These were unloaded by the power house cranes and moved to the permanent site on a truck designed for that purpose.

Those parts of the turbine equipment which are incorporated in the concrete were placed before the power house cranes were available. Owing to its size the speed ring came in sections which comprised: the upper stay ring, in five pieces; ten fixed

vanes, and the lower stay ring which supports the movable vanes. The turbine pit liners and draught tube liners were also received in sections.

The erection commenced with the placing of anchor bolts for the fixed vanes and lower stay ring. The vanes were then placed with upper ring and, after levelling and centering the whole assembly, the anchorages were grouted and the scroll case forms with upper pit liner placed.

Before concrete work proceeded the speed ring was braced in all directions with adjustable bars placed radially out from the upper ring to anchors in the scroll case floor, and a steel frame was bolted inside the upper stay ring flanges.

These measures were adopted to prevent possible distortion of the ring or movement in the whole assembly by the lateral pressure of the concrete as it was placed, which was done, in this case, from the centre of one unit to the centre of the next. The remaining turbine parts and the electrical equipment were placed with the aid of the two 90-ton power house cranes which could be used together and their combined capacity obtained by using an equalizer beam.

The head gates were shipped completely assembled and were placed, by a 35-ton locomotive crane, from the headworks deck. Voids were left in the concrete for the gate guides and sills, and these parts were grouted in place after adjustment to the anchors, thus securing a more perfect alignment than if placed integrally with the mass concrete.

Each of the four sluice gates came in three sections and the erection involved only the riveting of two horizontal seams, with frame connections, and the welding of these seams after the gates were completely assembled and lined. The towers and bridging above the gates had to be completely assembled on the job. The procedure with regard to placing the gate guides and sills was the same as that employed on the headgates.

The installation of other permanent equipment and structural steel presented no unusual features, most of the work being done by locomotive cranes.

Earth Dam

The earth dam extends along the Ontario shore from the end of the concrete dam, for a distance of 4,300 feet. The width of the crest is 15 feet and the slopes are 2½ horizontal to 1 vertical with the up stream face brought to a finished slope of 3 to 1 with handlaid rip rap.

The material underlying the site of the dam, also that in the proposed borrow pits, was thoroughly investigated by digging test pits and was found to be clay of an impermeable nature. The area within the lines of the base of the dam was stripped of all loam and vegetable matter by tractor drawn wheel scrapers and a cut off trench was excavated along the centre line of the dam. The stripping from the base of the dam and the borrow pits was used to make the embankment of the Canadian National Railway diversion, part of which parallels the dam.

The dam is constructed as a plain embankment without any special treatment other than compacting the material as it was deposited. The clay as taken from the borrow pits

was fairly moist and, after dumping, was spread in layers, 8 inches deep, by a blade grader hauled by a ten-ton tractor, and this machine travelling back and forth compacted the material.

A tractor drawn elevator grader operated in the borrow pit, excavating and loading the clay into 4- and 5-cubic yard trucks or into tractor wagons of 8 cubic yards capacity. Tractors were used to haul the wagons and all other equipment except trucks, and these passing back and forth over the embankment continued the work of compacting. Stone for rip rap was obtained from waste rock pile and cofferdams, which were being unloaded at the time rip rapping operations were underway. The rock was loaded by power operated equipment into standard gauge cars from which it was dumped down the slope of the dam, then hand placed to grades marked out by slope boards.

CONCLUSION

The foregoing description covers the chief features of the construction of this development which involved the placing of 95,000 cubic yards of cofferdams to unwater the numerous channels; the removal of 300,000 cubic yards of rock from the foundations of the permanent structures; the mixing of over 240,000 cubic yards of concrete and its distribution from a central plant to all parts of the work for distances which reached nearly two miles, most of which concrete was reinforced and required the incorporation of over 3,100 tons of steel; the placing of 11,000 tons of equipment and structural steel and the excavation of 186,000 cubic yards of material for the construction of an earth dam. In addition to these works there were a number of other activities in connection with the development, which space does not permit of mentioning in detail but which may be summarized briefly.

Of these, the construction of two small concrete and three small earth dams which were placed across subsidiary channels at the outlet of the Mississippi River might be mentioned. Part of the flow of the Mississippi formerly passed through these channels to the Ottawa River below Chats Falls and by the construction of these dams the whole flow was diverted to Chats Lake.

At the outlet of Chats Lake some 28,000 cubic yards of rock were removed from the channel to reduce the loss of head between the lake and power house, so that the level of the lake can be maintained at its normal elevation during flood periods by regulating the flow at the dam.

Construction methods on these two works were similar to those at Chats Falls and required independent plant and camps.

Other work was the diversion of over two miles of the Canadian National Railway; the installation of booms and piers for logging operations, and the construction of a number of houses for operating staff.

In reviewing the manner in which the work was done on this development there are certain factors which may be recognized as being responsible for the quality of the work and the successful conclusion of the construction on a project of this size. These may be enumerated as follows:

1. Power operated equipment was

used wherever possible for the handling and erection of construction materials and the permanent equipment. Standard gauge tracks were laid to reach the greater part of the work and their installation proved economical, over 300,000 tons of freight having been handled over them.

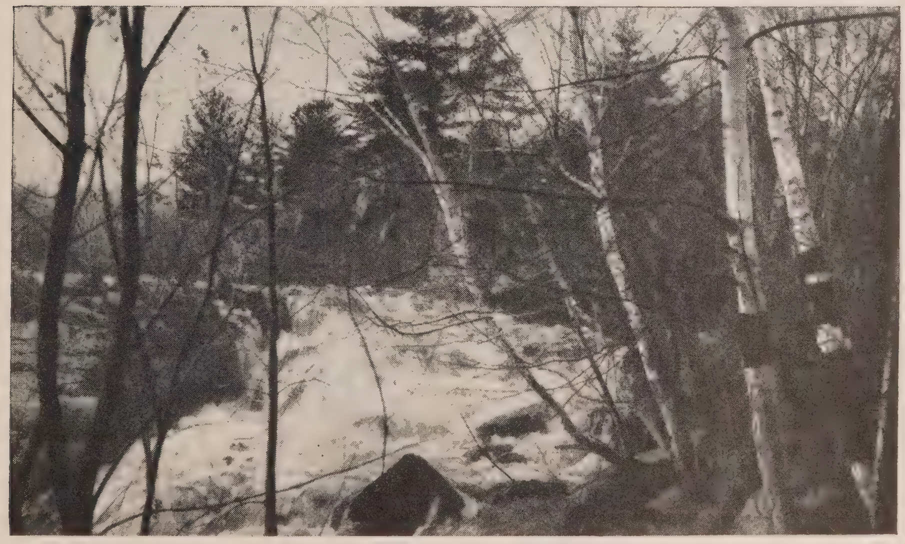
2. The layout of a central concrete mixing plant with stone crushing plant was designed to operate with a minimum of labour.

3. Light railway equipment was used to deliver the concrete directly to the forms.

4. Horizontal joints in the concrete structures were eliminated by placing concrete continuously, and, with the precautions taken at all vertical joints, leakage was prevented.

5. The heating of concrete aggregate and the protection of the forms from frost during winter operations was accomplished without serious increase in cost.

6. Concrete operations were controlled by careful inspection during the mixing, placing and curing operations. This resulted in the production of concrete of uniform high quality and the elimination of delays, etc., in the progress of the work.



Time Factor in Preparing for Additional Capacity

By G. L. Knight, Vice-President, Brooklyn Edison Co.

WITH the upturn of utility load curves now so generally evident, every prudent operating executive is considering how his company will stand with relation to load versus capacity when the present surplus is reduced to the danger point.

If the present trend continues to evidence a definite and permanent business improvement and if reports show that the dead line will be reached before the winter of 1935-36, it is not now too soon to start serious consideration of what is best to do to meet the situation.

In every large operating company some one of the department heads, usually the electrical engineer, is charged with the responsibility of following the load growth in relation to station and line capacity, estimating future load and predicting the time when additional capacity will be required. When it is reported that the maximum demand will have passed the safe limit of station capacity less adequate reserve by a given date, it is shown that some minimum kilowatts in additional generating capacity, feeders, etc., are required to be operative before that date.

Such reports must, of course, be brought forward long before the new equipment is actually needed as it takes time to develop plans, to obtain estimates from adequately prepared plans and specifications, to secure appropriations, and to place orders with manufacturers and contractors.

In a compact self-contained organization where operating and engineering executives as well as department heads are constantly on the property, such reports are followed promptly by the bringing forward of engineering studies to show what capacity and of what character and cost is best fitted to answer the requirements.

Hurried plans and snap decisions cannot produce the best results, hence studies and plans should be started early enough to have plenty of time to develop the facts for reaching well-considered decisions and still meeting the necessary operating date. Preliminary inquiries will always show how much time is necessary for complete engineering, for equipment delivery, and for construction and assembly of all the elements. Complete time schedules can then be prepared to convince any executive that the time has arrived for action if the operating company is to maintain its reputation for adequate and reliable service.

It makes little difference except in time as to what type of equipment is being considered, in every case the preliminary engineering studies made as soon as the need for additional capacity is evident will determine the time interval between the report and the operating date. Since this interval may vary from 1½ to more than

2 years, depending on the economics of any given situation and may be modified by executive judgment, it is of the utmost importance to get an early start on the work.

At the time such facts are presented, it is possible and entirely practicable to have a complete project ready for authorization covering the estimated cost of every part of the work. This practicability has been demonstrated by one utility in four major operations over an eight-year period, during which over 500,000 kw. of equipment were added to the system. In the above case, projects, made up of as many separate work order requests as appeared necessary to cover the various parts of the work, were presented immediately after the preliminary investigations had fixed the size and type and approximately two years ahead of the operating date. Appropriations were secured and fully co-ordinated programs worked out, resulting finally in meeting each operating date with margin and completing the work within the cost estimated in the original appropriation.

Such a program and such results are surely to be desired from both executive and operating standpoints. They can be accomplished with proper organization backed by effective executive support, provided always that the company has sufficient earning power to find a ready market for its securities and thus be able to secure capital as required for its needed additions to plant and property.—*Electric Light and Power.*

Cooking Classes, Range, Refrigerator and Water Heater Demonstration

The Commission has been co-operating with the Provincial Agricultural Department in arranging a tentative itinerary of two-day cooking classes extending over a period of ten weeks. Three teams will be conducting these classes under the auspices of the Provincial Government in co-operation with the Hydro-Electric Power Commission of Ontario and manufacturers, and under the slogan: "Provincial farm products for Ontario people".

The ranges used will be distinctive types of the latest developments; the refrigerator, a standard domestic model with up-to-date improvements, and the water heater, that which the Commission is offering to and installing free for its consumers everywhere in Ontario.

It is proposed they will start at an early date, beginning in the counties of Grey or Bruce in the north, Wellington or Dufferin in the centre, and Prince Edward or Hastings in the east. The programme includes the following places, but it may be necessary to change locations to meet conditions and avoid interference by local fairs and functions.

Team A-1

Place	*County*
1. Dutton	Elgin
2. Essex	Essex
3. Ridgetown	Kent
4. Petrolea	Lambton
5. Thedford	Lambton
6. Embro	Oxford
7. Tillsonburg	Oxford
8. Jarvis	Haldimand

9.	Dunnville	Haldimand
10.	Thorold	Welland
11.	Beamsville	Lincoln
12.	Glanford	Wentworth
13.	Paris	Brant
14.	New Hamburg	Waterloo
15.	Milverton	Perth
16.	Wingham	Huron
17.	Harriston	Wellington
18.	Walkerton	Bruce
19.	Tara	Bruce
20.		Grey

TEAM A-2

	Place	*County*
1.	Picton	Prince Edward
2.	Stirling	Hastings
3.	Napanee	Lennox and Addington
4.	Sydenham	Frontenac
5.	Elgin	Leeds
6.	Brockville	Leeds
7.	Kemptville	Grenville
8.	Perth	Lanark
9.		
10.	Cobden	Renfrew
11.	Arnprior	Renfrew
12.	Carp	Carleton
13.	Winchester	Dundas
14.	Moose Creek	Stormont
15.	Alexandria	Glengarry
16.	Vankleek Hill	Prescott
17.	Russell	Russell

Three to be added.

TEAM A-3

	Place	*County*
1.	Hillsburg	Wellington
2.	Shelburne	Dufferin
3.	Durham	Grey
4.	Markdale	Grey
5.	Stayner	Simcoe
6.	Barrie	Simcoe
7.	Midland	Simcoe
8.	Sunderland	Ontario
9.	Lindsay	Victoria
10.	Fenelon Falls	Victoria
11.	Millbrook	Durham
12.	Norwood	Peterboro
13.	Brighton	Northumberland
14.	Cobourg	Northumberland
15.	Brooklin or Whitby	Ontario
16.	Markham	York
17.	Mount Albert	York
18.	Woodbridge	York
19.	Brampton	Peel
20.	Milton	Halton

The hearty co-operation of all Hydro commissions, committees and others interested is desired in carrying on these classes and demonstrations to assure a maximum of attendance.

THE BULLETIN

Published by

HYDRO-ELECTRIC POWER COMMISSION of Ontario

620 University Ave. Toronto

Subscription Price $2.00 Per Year

Abitibi Canyon Development

By J. R. Montague, Hydraulic Department and G. H. Bradshaw, Electrical Engineering Department, H.E.P.C. of Ont.

THE Abitibi Canyon Development is located on the Abitibi River in the James Bay drainage area about three and one-half miles from Fraserdale station on the T. & N.O. Railway, or approximately 70 miles north of Cochrane. The site possesses natural advantages for the construction of a power development, in that the river channel at this point is confined to a narrow gorge, the rock walls of which rise some 150 feet above the river bed.

Work on this project was started in the spring of 1930. The first unit was placed on load in May, 1933, and the second unit in August. The general arrangement of the development consists of a concrete gravity type dam across the main section of the gorge, with a sluiceway section joining this central gravity section on the east. From the sluiceways the surplus river flow is conveyed to the lower river through what is known as the highwater channel. There is a rolled fill embankment with a long concrete retaining wall extending west from the main dam, and a similar earth fill section running east from the sluiceway section.

The power house is located in the gorge immediately adjacent to the main dam section, the river bed having been excavated to provide a satisfactory tailrace channel which extends downstream for a distance of some 1,500 feet.

The penstock intakes are located in the upper portion of the gravity section of the main dam, feeding through racks and headgates. Steel plate penstocks, 18 feet in diameter, lead down the face of the dam to the power house substructure, where they join to the steel plate scroll cases incorporated therein. These penstocks are protected from extreme low temperatures by a continuous roof which extends over the entire penstock area. This roof is supported on steel columns, and consists of I-beam purlins carrying Aerocrete slabs, which are protected from the weather by a heavy coating of gunite.

The development is designed and constructed for an ultimate installation of five units, the installation of

CONTENTS

Vol. XX No. 10
OCTOBER, 1933

two of which is now completed. Each of these units has a rated capacity of 66,000 brake horsepower at 150 rev. per min., under a net head of 237 feet, representing a total installed capacity of 330,000 brake horsepower.

The plant is served with a standard gauge railway spur from the site to Fraserdale, where it joins the T. & N.O. Railway. Construction power was transmitted over a temporary wood pole transmission line from the Abitibi Electric Development Company, Limited, plant at Island Falls, some thirty miles distant. The machine shop, concrete and stone crushing plant, camps and other services, are located for the most part on the plateau immediately west of the dam. The forebay created by this development has an area of approximately 2,000 acres, flooding out the Lobstick, Burnt Wood, Birch and Oil Can Rapids, and extending upstream practically to the Island Falls tailrace.

The sluiceways, of which there are five, each with a clear opening of 45 feet, are capable of discharging a maximum flood flow of 150,000 cubic feet per second, all of which as previously mentioned is conveyed to the river at a point considerably downstream from the plant, in order to minimize the backwater effect in the tailrace. The highwater channel through which these flood flows are conveyed is located well back from the edge of the east bank of the

Fig. 1—Main dam, sluiceway, high tension switching structure and unloading crane over power house, operators colony and construction plant in the background.

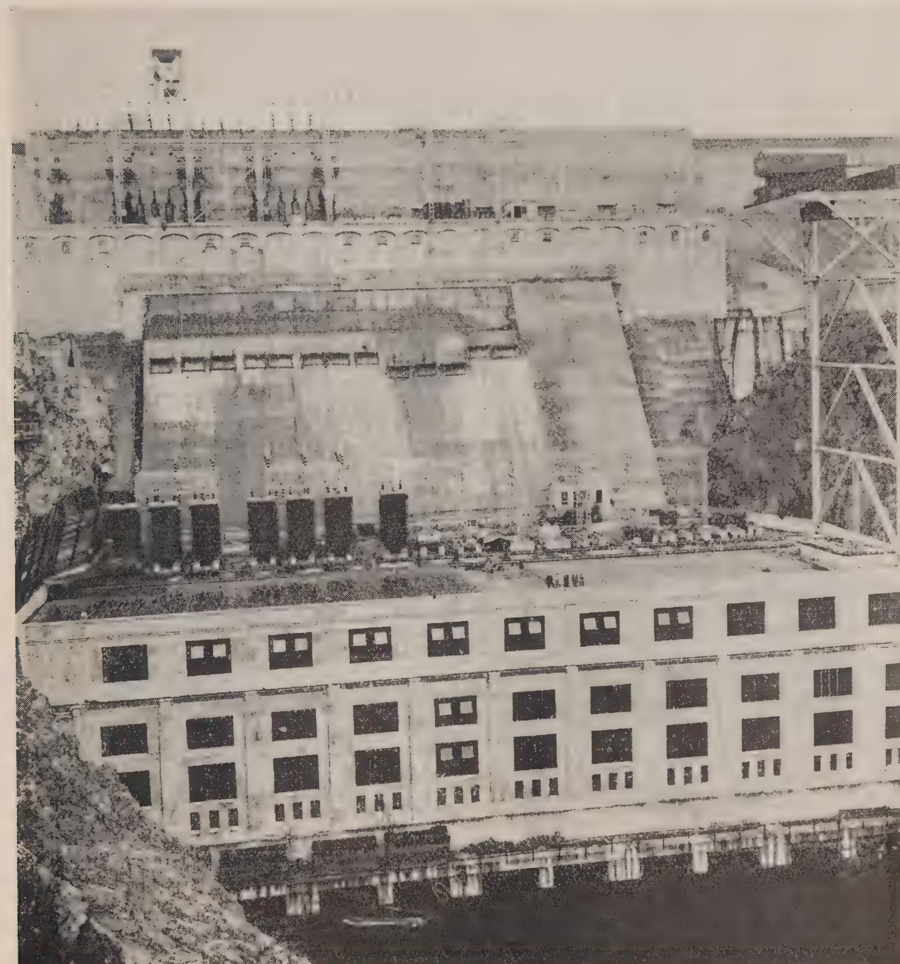


Fig. 2—Power house and part of the headworks from downstream.

canyon. It is formed partly through the excavation of a rock channel, and partly by the construction of concrete gravity wall sections along the sides where necessary to prevent overtopping.

CONSTRUCTION

Actual construction work was started in the late fall of 1930. The first work to be undertaken consisted of driving two unwatering tunnels for the purpose of carrying the flow of the river around the site of the development. Concurrently with this work, foundations were placed for the erection of a temporary double track steel railway bridge across the canyon. Both the tunnels and the bridge were completed in the spring of 1931. Cofferdams were also constructed during the winter months below the south and above the north portals of the unwatering tunnels, and work

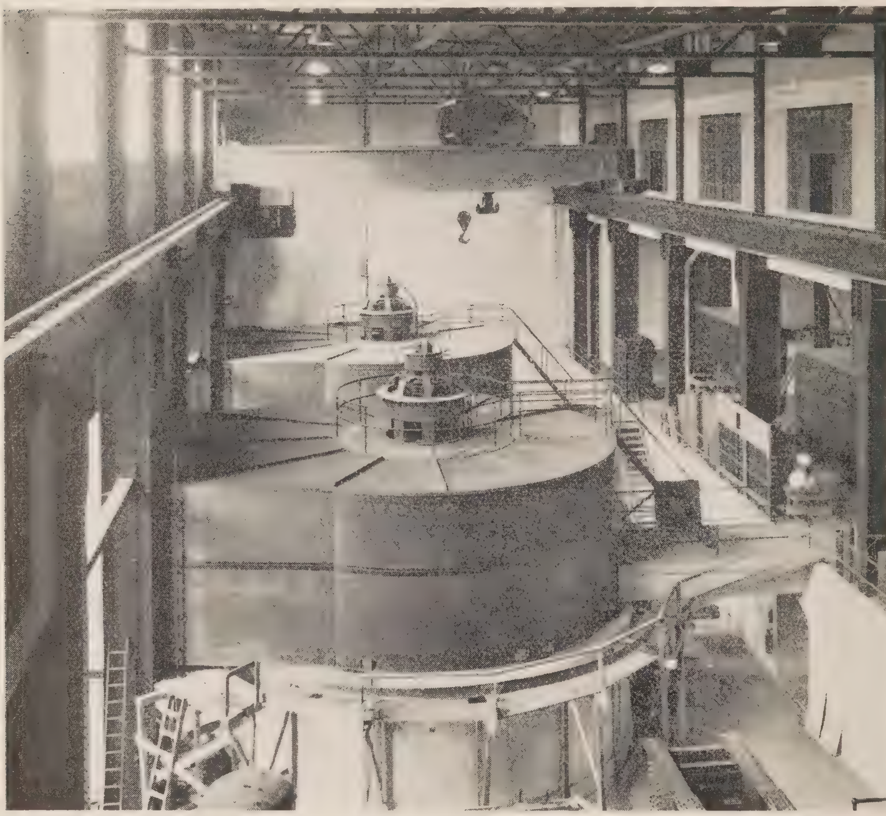


Fig. 3—Interior of power house showing the two generators installed.

started on the power house and dam excavation.

Concrete for the dam was started in the early fall of 1931, and was completed for the most part in the spring of 1932. This included the placing of the concrete also in the sluiceway, retaining walls and high-water channel walls. The closure gates at the upper portals of the unwatering tunnels were closed in the early part of June, 1932, and the water raised in the forebay. Very little trouble was experienced in the carrying out of this forebay flooding, and concrete plugs were subsequently placed in the tunnels to render them permanently watertight.

In carrying out this work a total of 1,240,000 cubic yards of earth and rock was excavated, and 527,000 cubic yards of concrete was placed.

Electrical Features

The complete development, as designed, contains a total of five generators, five transformer banks and four high voltage lines, of which the original installation, now in operation, consists of two generators, two transformer banks and two lines.

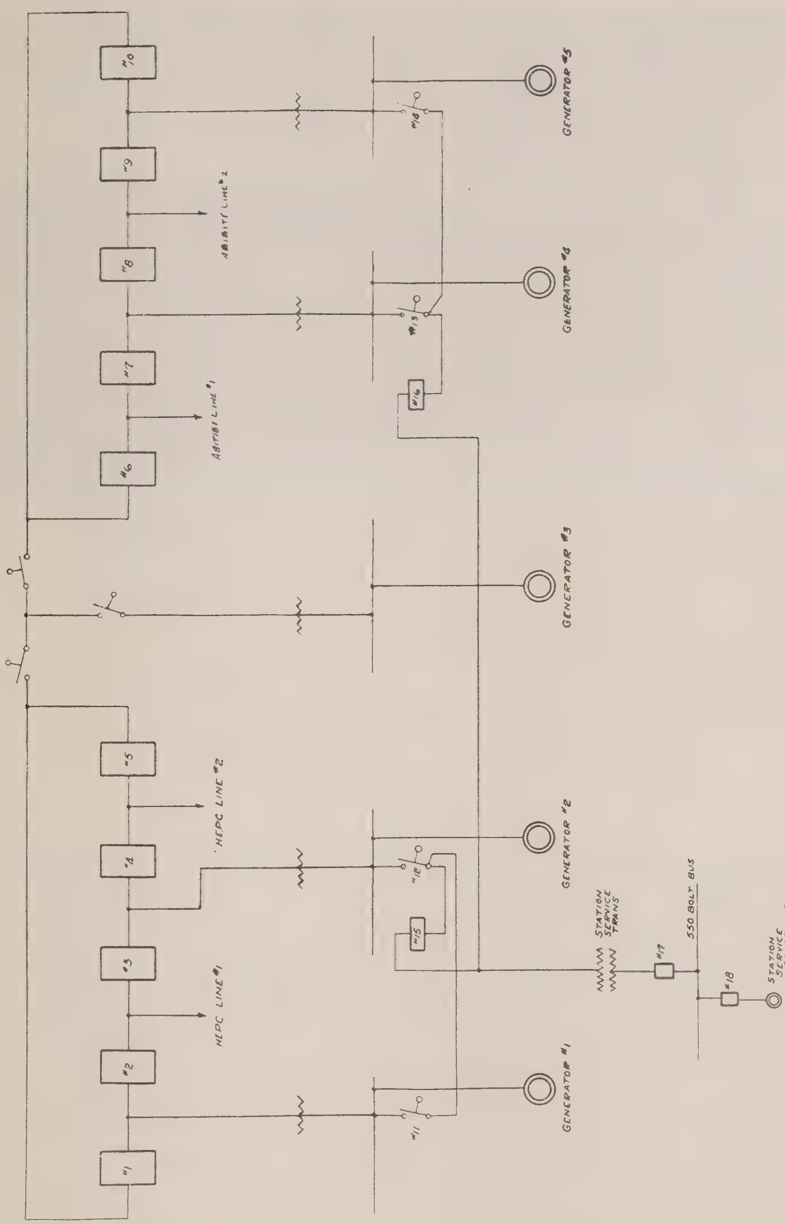


Fig. 4—Elementary station wiring diagram.

Superstructure

A view of the development taken from the north or downstream side (Fig. 2) shows the powerhouse with two transformer banks and one spare in position on its roof, part of the high voltage switch structure and the head works. The generator room is 225 ft. by 52 ft., with the units spaced 45 ft. apart and mounted on concrete

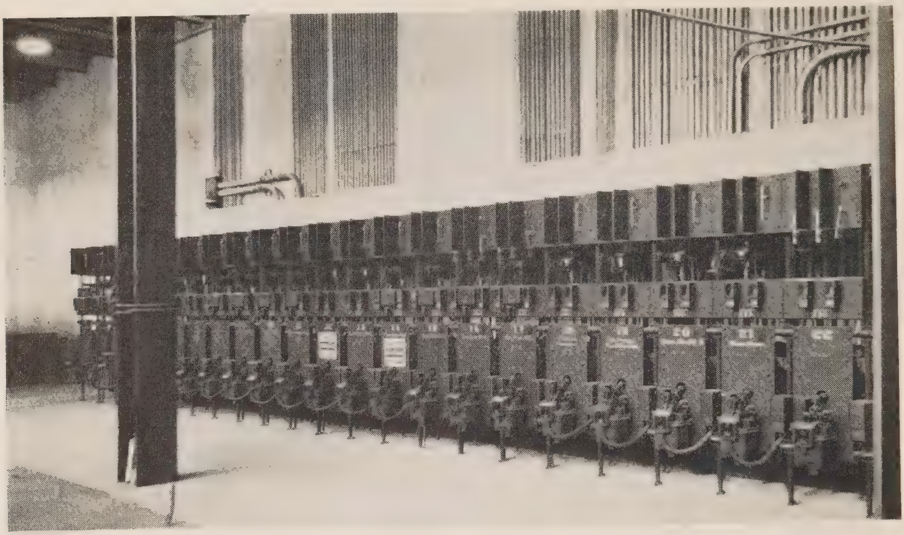


Fig. 5—Service switching structure consisting of 22 pipe mounted, 550 volt breakers.

pedestals at El. 429.5. The operating gallery is on the downstream side at El. 420, with a piping gallery at El. 410. Directly south of the generator room are four floors, the pump tunnel El. 420, the 13.8 kv. equipment and station service El. 432, the control room and offices El. 455 and a piping tunnel for the transformers at El. 469.

The powerhouse roof is at El. 480 and it was considered necessary to apply a special roofing as there would be considerable traffic to equipment. It is also expected that snow will accumulate requiring shovelling. The usual tile or slate roof surface was not deemed practicable due to the wide variation in temperature. A wearing surface over the tar felt roof covering was applied, consisting of one-inch of tar and crushed stone dressed with a tar and sand mixture. This method of surfacing is similar to that extensively used in road surfacing or retreading and, as it is believed to be new to powerhouse roofing practices, the result will be watched with interest.

MAIN GENERATORS

The generators (Fig. 3) are rated 48,500 kv-a., 85 per cent. power factor, 150 rev. per min., 13,800 volts, 25 cycle and are directly connected to a main exciter rated 180 kw., 250 volts and a sub-exciter rated 7 kw., 250 volts. A steel cubicle structure for each generator is installed on El. 432 approximately 42 ft. south of the longitudinal centre line of the units and has separate compartments for incoming generator main leads, potential transformers, outgoing transformer leads and station service supply oil breakers and potheads. The only means of isolating a generator from its transformer bank are single pole, hand operated disconnecting switches. The main leads between the generator and its cubicle consist of two ¼ by 4 inch copper bars per phase supported on 23 kv.

insulators in a horizontal cell structure immediately below the floor El. 432.

Louvres in the downstream wall supply outside air to an enclosing steel shield around each generator. The air is forced through the machine from the top, passing through steel ducts below and may be freed either inside or outside the generator room through other sets of louvres.

Main Transformers

The connections between the cubicle and transformer bank are made with 1,500,000 cir. mils stranded copper cable, paper insulated, lead covered and there are three cables per phase each approximately 70 feet long. The transformers are installed on the roof, El. 483 and each bank has three 16,000 kv-a., 13,800 delta/-132,000 volt star, water cooled transformers. An openly constructed copper bar low voltage delta bus is installed adjacent to the low voltage bushings. Because of the great changes in temperature during the year, it was decided to add expansion joints between the cable potheads and the delta bus. A set of high voltage lightning arresters is installed directly south of each transformer bank.

High Voltage Switching

An elementary station wiring diagram (Fig. 4), in which the high voltage transformer and breaker isolating disconnecting switches have been omitted, shows the arrangement of the high voltage switching. There are two ring busses, each with five oil circuit breakers and each being fed from two units and supplying two lines. Bank No. 3 may be connected by motor operated disconnecting switches to either ring bus or may be split between the two.

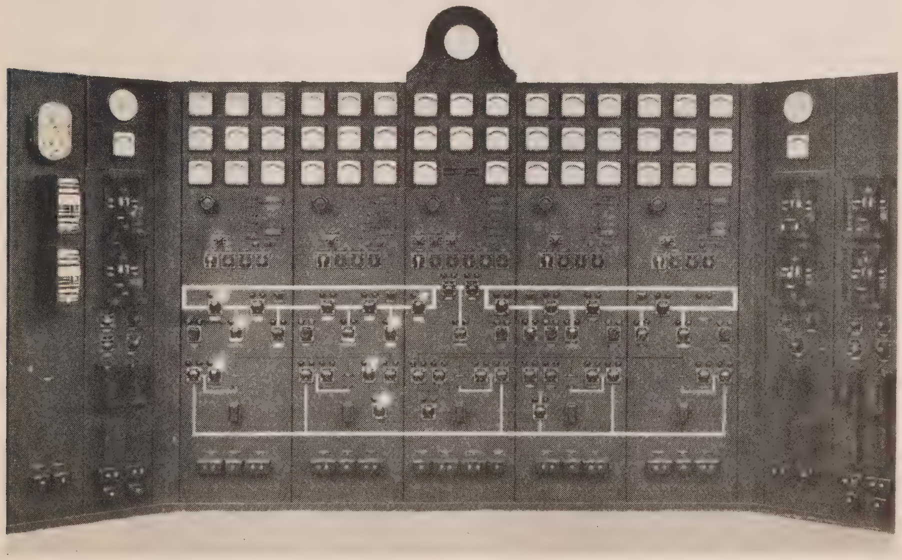


Fig. 6—Centre section of main switchboard mounting main control and indicating meters.

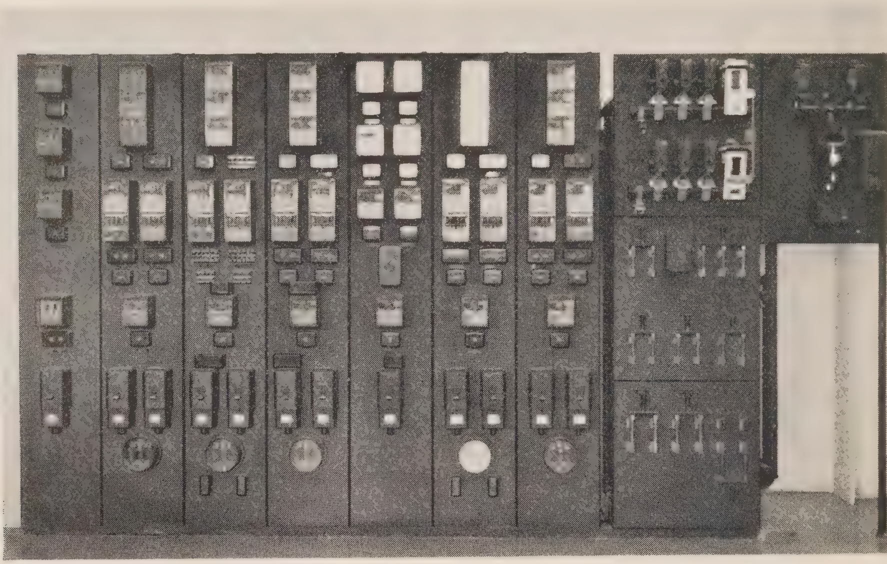


Fig. 7—Generator relay board, battery distribution switch panel and service generator field switch panel.

Station Service

The station service is normally supplied by a three phase, 450 kv-a., 13,800/550 volt transformer with an automatic tap changer device having eight high voltage full capacity taps approximately 2½ per cent. for full kv-a. capacity below normal voltage. As a standby, there is also installed a 500 kv-a., 550 volt service generator, waterwheel driven. A twenty-two oil switch service structure, pipe mounted, is installed on El. 432 (Fig. 5) and supplies the various service loads throughout the development. A standby motor generator exciter set, consisting of a 270 h.p., 550 volt induction motor, and a 180 kw., 250 volt shunt wound generator is provided with suitable switching so that it may replace any direct connected main exciter in case of failure.

An interesting scheme of automatic supply of 13,800 volt generator power to the service bank may also be seen in Fig. 4. This supply may be from either generator of pairs 1, 2 or 4, 5. For each of these pairs an electrically operated disconnecting switch is connected to the generator bus at the cubicles with the transformer sides connected in parallel to an oil circuit breaker. The transformer sides of the two oil breakers are also connected in parallel to the service bank. The pair of breakers are electrically interlocked so that either cannot be closed if the other is in the closed position. An auxiliary switch on each breaker prevents either of the pair of associated disconnecting switches from being opened or closed electrically while the breaker is closed. Each pair of disconnecting switches is also electrically interlocked to prevent the closing of either one when the other is closed.

In case of a shut-down due to relay operation of the main generator to which the station is connected (for example generator No. 1), the station service breaker No. 1 would open and breaker No. 2 would close, connecting the station service to generator No. 4 or No. 5 depending on which set of disconnecting switches is closed. This throwover scheme will be inoperative if the station service generator breaker is closed, or if the breaker has been tripped due to the operation of the overcurrent relays. Suitable under-voltage relaying on service feeders prohibits trip out for low voltage during the short interval between the opening of one breaker and the immediate closing of the other.

Switchboards

The control room is at the centre of the power house on El. 455 with the main vertical switchboard shaped like five sides of an octagon. The centre section (Fig. 6) is a five panel main control and indicating meter board, one panel for each main unit. The first section to the left is also of five panels and contains the voltage regulators, recording and watthour meters of generators 1 and 2, and totalizing meters for the two lines from No. 1 ring bus. The next section is a four panel board for station service equipment. The two sections to the right are each five panels, the first corresponding to the left with equipment for generators 3, 4 and 5; and the second, the meters for No. 2 ring bus lines, the station 120 volt storage battery equipment, the generator ground detector relays and the relay annunciator signal panel.

To the east of the main switchboard is the generator relay board of 7 panels with a battery distribution switch panel with automatic emergency lighting throwover switching and a small panel for the service generator field switch at the right, (Fig. 7). All panels are of stretcher steel except the latter two. The high voltage bus and line relays are installed on a five panel board located in a small room beneath the high voltage breaker platform at El. 596.

Relay System

All relays are modern high speed instruments and complete zone and back-up protections on the main equipments are provided. A complete system of automatic throwover is supplied for the high voltage bus protection of No. 3 unit to provide adequate protection for all connection conditions of No. 3 bank. Two sets of instantaneous overcurrent relays are supplied, one for each ring bus. When No. 3 is supplying either one of the two ring busses the current transformers on the transformer neutral are connected to the correct secondary differential loop through contacts of the electrically operated disconnecting switch controller, closed to that particular ring. When the two rings are paralleled an interlocking switch will cut out one of the sets of relays.

Directional distance induction type relays afford phase to phase and phase to ground protection on each line with balanced current protection in phases and in ground for each pair of parallel lines.

Each relay has an operation indicator and the operation of each protection is signalled in the control room by an individual light and an alarm bell.

Fig. 8—100 ton unloading crane.

Oil Systems

Each generator has a self-contained unit circulating system. Storage tanks are installed at the west end of the piping tunnel El. 410 with feed and return mains to replenish or empty any unit system. Duplicate motor gear pumps maintain circulation in each unit system with the suction of the pumps connected to the good oil side of a cloth bag type filter. Normal operation is with one pump but on cessation of flow the duplicate pump is automatically started. A 5 gal. per min. portable filter press is provided and is normally located in the lubricating oil room.

Three transformer oil storage tanks, two of 7,000 gallons and one of 4,000 gallons capacity, are in an oil room at the west end of El. 455. A 40 gal. per min. filter is permanently located in this room with suitable transformer piping headers and connections installed along the pipe gallery at El. 469.

Two circuit breaker oil storage tanks of 4,000 gallons each, together with a permanent 20 gal. per min. filter press, are installed at the west end of the tunnel at El. 596, with suitable piping headers along the breakers. Flexible hose connections from a common valve station adjacent to each breaker, service the individual breaker tanks.

Cranes and Elevator

There are two generator room cranes, each of 130 tons capacity. In handling the generator rotor, both cranes are used with an equalizer beam having a capacity of 230 tons concentrated at the centre.

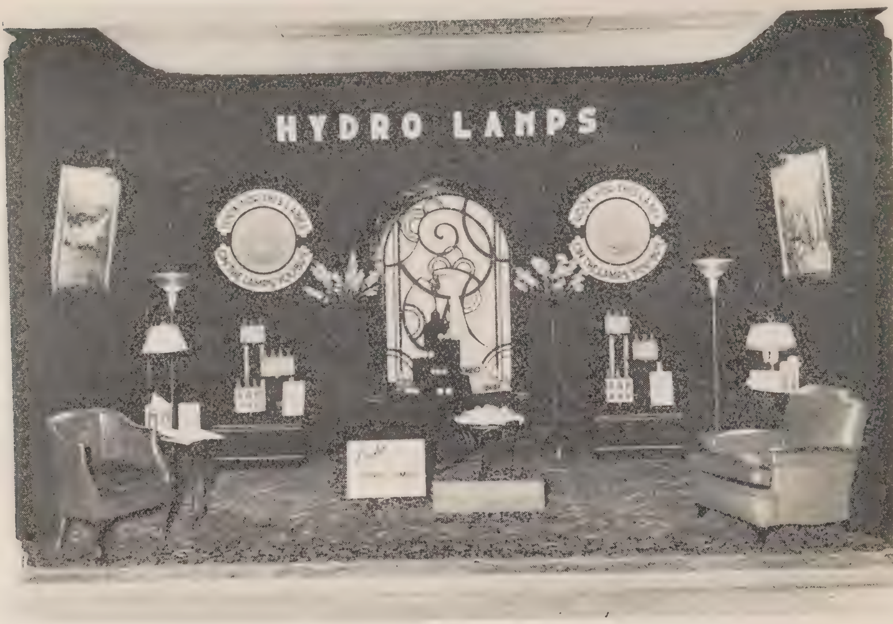
An unloading crane of 100 tons capacity and with a lift of 177 feet was installed on top of the canyon shore with a runway extending out over the power house (Fig. 8) to facilitate the handling and erection of the generator room cranes and all power house major equipment. The runway structure spans the railway

track and the power house end is supported by two structural steel columns, securely braced together and sitting on concrete at elevations 479 and 420. Heaters are supplied for all gear cases and in the totally enclosed operators' cage.

The elevation of the dam at the head works is 654.33 and an electric inclined elevator allows entrance to the power house. The car is capable of lifting a maximum load of 6,000 pounds, besides its own weight and can travel at a speed of 150 feet per minute. The car moves approximately 250 feet, serving six landings, at an incline of 53 degrees from the horizontal.

The original plant was designed by Mr. George F. Hardy, Consulting Engineer of New York City, and the construction work was carried out by the Dominion Construction Corporation, Limited, for the Ontario Power Service Corporation, Limited.

Abitibi Canyon before development, taken at foot of canyon at site of development looking upstream.



Hydro-Electric Power Commission Lamp Exhibit at Canadian National Exhibition, 1933.

Booth at Canadian National Exhibition, 1933, showing domestic water-heaters as installed under the Commission's free installation plan.

Hydro-Electric Power Commission of Ontario booth at Canadian National Exhibition, 1933, showing automatic pumping, grain grinding, under-earth heating and milk cooling equipment.

Perennial Gardens, Exhibition Park, Toronto.

Some Phases of the Financial Operations of the Commission

By W. G. Pierdon, Accountant, H.E.P.C. of Ont.

(Address to Association of Municipal Electrical Utilities at Windsor, Ont., June, 23, 1933.)

IT is my purpose to deal briefly with a few of the financial phases of our co-operative Hydro undertaking, such as the practice followed in obtaining funds for capital expenditure purposes; the interest or carrying charges on these funds; and the procedure followed in respect of the retirement of these obligations which are assumed by the Commission on behalf of the Hydro municipalities. Such a review will involve a consideration of some aspects of the employment of revenue.

More than twenty-five years ago the pioneers of the Hydro enterprise, in order to establish the undertaking upon a firm foundation, sought to ensure that capital could be obtained in a manner that would contribute to the securing of low-cost power to consumers. Many of the earlier difficulties were overcome as they arose and consequently of recent years the municipalities have not been confronted with the detailed difficulties that characterized some of the earlier years. The matters of obtaining the necessary capital and making provision for its retirement are, however, still fundamental to the success of Ontario's municipally owned Hydro undertaking.

Capital, as you are well aware, is required for two main purposes:—

First—For expenditures in connection with the construction of generating plants, transformer stations and transmission lines, and for the acquiring of right-of-way in connection with the transmission networks, and other costs incidental to construction. In connection with these requirements the Commission obtains advances from the Province of Ontario.

Second—For the purchase of such undertakings and companies as are acquired by the Commission in connection with its general power programme. In this connection the Commission issues debentures guaranteed by the Province and, in addition, the Province guarantees certain bonds and debentures already existent and which the Commission necessarily has had to assume in connection with various properties it has acquired. Practically all of such bonds and debentures issued or assumed by the Commission up to the end of the last fiscal period represent the purchase price of certain large properties of the Niagara System, such as the Ontario Power Co., The Toronto Power Co., and the Dominion Power and Transmission Co.

The capital liabilities of the Commission, then, consist of cash advances made by the Province and of bonds and debentures issued or assumed by the Commission and guaranteed by the Province.

The cash advances made by the

Province constitute the major part of the Commission's capital liabilities. As at October 31, 1932, these advances amounted approximately to $204,000,000; while the bond liability amounted approximately to $61,000,000.

The Practice Followed in Obtaining Advances from the Government

Briefly, the practice followed in securing advances from the Government for the purpose of the capital expenditures of the Commission is that the Commission, from time to time,—usually twice a year (April and October)—requisitions the Government to advance the moneys required, and such advances are then made by the Province from funds that have previously been appropriated for this purpose by vote of the Legislature.

In order to ensure that requisite funds are made available by legislative vote to meet the Commission's construction programmes, the engineers, some considerable time in advance of actual requirements, prepare estimates of the amounts of money required for the Commission's purposes. These estimates are submitted to the Government in detailed form, naming each system and describing fully the nature of the work for which funds should respectively be made available. These estimates are the bases for legislative consideration and, when governmental sanction has been given, the funds thus provided are made available to be drawn upon by the Commission. When drawing upon these appropriations the Commission must prepare its requisitions in strict conformity with the estimates and must confine its construction expenditures on behalf of the various systems to the amounts respectively set forth therein.

When in exceptional circumstances funds provided in any fiscal year by vote of the Legislature for construction work of the Commission become exhausted; or when it is found to be necessary and expedient to proceed with the construction of certain works, for which funds have not been provided, the Government has provisions under its Audit Act whereby funds can be made available to the Commission upon receipt by the Government of the Chairman's report showing the necessity for such additional moneys.

If, on the other hand, the Commission has requisitioned and obtained funds from the Government which, at the end of the fiscal year, are found to be in excess of its requirements in respect of any construction work, such excess amounts are returned to the Provincial Treasurer.

If the appropriations by the Legislature for the construction purposes of the Commission are not entirely used up within the Government's fiscal period—a period to which the Commission's financial year conforms—then all unexpended or unused appropriations are automatically cancelled and are thus no longer available to the Commission. Each year must stand on its own fiscal basis.

In the section of the Twenty-fifth Annual Report commencing at page 252, you will find comprehensive statements appertaining to what I have been saying, and these include

the details of appropriations, advances and capital expenditures for each of the Commission's systems. Similar statements appear in all the Commission's Annual Reports to the Government.

The object of this short review is to make it perfectly clear that the funds provided through the Government are necessarily spent under specific authorizations, and are not available for working capital or for any other purpose.

Interest and Other Expenses Incidental to the Providing of These Funds

We come next to the subject of interest and other expenses incidental to the advances from the Government and we shall consider, also, the allocation of these costs to the various systems.

As you are aware, the Hydro undertaking is self-supporting and all costs are met by the consumers who ultimately use the electrical service. Whatever costs the Government has incurred in providing capital for the construction work of the Commission must be reimbursed by the Commission acting as trustee for the co-operating municipalities on behalf of whom all the obligations have been incurred.

Two sections of the Power Commission Act govern the Commission's procedure with respect to the collection and payment of interest. They are as follows:

Section 35 of the Act states:

> "The Commission shall pay annually to the Treasurer of Ontario, as interest on the indebtedness of the Commission to the Province, such sum as may be from time to time determined by the Lieutenant-Governor in Council to be sufficient to reimburse the Province the full amount of interest paid by the Government on moneys raised for the purposes of the Commission and the charges incurred by the Government in providing such money."

and

Section 56B provides that the price payable for power by any municipal corporation shall include:

> "interest at the rate or rates payable by the Commission upon the money expended by, or the obligations assumed by, the Commission in the construction or purchase of works, and upon all such other expenditures as the Commission may make under the provisions of this Act and upon working capital."

Interest is the largest single item of expense entering into the cost of power. The magnitude of this expense may be appreciated from the fact that in the year ending October 31st, 1932, the Commission paid in interest about $14,800,000, of which amount the Province received something over $12,100,000 in interest on money it had advanced. The balance of $2,700,000 was paid to holders of bonds issued or assumed by the Commission in respect of power properties acquired.

At the end of each fiscal year the Government forwards to the Commission a statement of the interest payable for the period. This statement shows the moneys advanced year by year with the rates of interest respectively applicable to each

amount advanced. These rates applied to the various yearly advances give the total interest obligation of the Commission to the Government. To this amount there is added a share of the Government's yearly expense incurred in connection with exchange and bank charges. The Commission's share of exchange and bank charges is arrived at by using the percentage that the advances to the Commission from the Province bear to the total borrowings of the Province. For example, at the end of October, 1932, the Commission's debt to the Province was equal to 42.16 per cent. of the Province's debt, and, therefore, the Commission was required to assume this percentage of the exchange and bank charges paid by the Province in the year.

The allocation of this expense to the cost of power is taken care of in two steps. The first step is the determination of the proper share chargeable to each system; and the second is the detailed allocation of the charges to each of the properties within the various systems.

Inasmuch as practically all of the interest expense in respect of bonds is a direct charge upon the revenue of the Niagara system, the distribution of this as part of the cost of power service requires no particular consideration or attention as it simply follows the distribution of the capital involved. However, on account of the variation in rates prevailing from year to year in respect of advances from the Province, and in view also of the fact—as has already been explained—that the yearly advances to the Commission can be expended only for the purposes for which they were made available, special care is exercised in the allocation of the annual interest expenses so as to ensure that each system is charged only with its proper and equitable share. In this connection the Commission maintains a record of each year's advances to the respective systems. By applying the interest rate applicable to each year's advances on behalf of each system the total amount of interest chargeable in the year to each system is ascertained.

Once the amount chargeable to any system is so determined, an average rate per cent. on the total operating capital is deduced, and this rate is then used in determining the amounts of interest to be distributed to the various units of property within the respective systems in proportion to the capital respectively invested therein, and such expense then becomes a definite part of the operating costs of that particular section of plant.

Sinking Funds

We come now to the collection and investment of sinking fund as currently provided by the municipalities in order to retire the Commission's bonded debt and also the advances from the Government. In this connection the Power Commission Act provides that the price payable for power service to municipalities shall include "an annual sum sufficient to form in forty years with interest" improvement "at four percentum per annum, a sinking fund for the repayment of the advances made by the Province of Ontario under this Act for the payment of the cost of the works and also for the repayment of

any other indebtedness incurred or assumed by the Commission in respect of the cost of the works."

This act came into effect in the year 1926 and, as will be observed, establishes a common period of 40 years for the collection of sinking funds for the repayment of capital liabilities in respect of all systems. This applies not only to cash advances from the Province but to all other funded debts represented by bonds and debentures issued or assumed by the Commission.

It will add somewhat to your understanding of the present situation if I draw attention to the fact that in 1926 a change was made in the details of procedure which formerly prevailed to those which now obtain.

The provisions of the Power Commission Act in respect of sinking fund during the period up to the end of 1925 were applicable only to cash advances from the Province, the terms of which called for retirement of these advances in a period of 30 years. The Commission collected various sinking funds on this basis from 1912 to 1925. In the last few years of this period large capital expenditures aggregating about $112,000,000 were made in the Niagara system for the construction of the Commission's Queenston Power plant and for the acquirement of the Toronto Power and Ontario Power plants. These circumstances called for special consideration and it was eventually decided to adopt a 40-year period for the retirement of all of the Commission's capital liabilities. The reasons for this decision, briefly stated, are as follows:

FIRST—The Commission felt that to retire its obligations in respect of these large permanent works in a period of 30 years would be an unduly heavy charge upon the cost of power.

SECOND—Prior to the time of merging the Ontario Power and Toronto Power plants with the Niagara system, a variety of rates were in use in the calculation of sinking funds in respect of the funded debts of these two properties. When the properties were merged with the Niagara system it became apparent that the continued use of several rates tended to confusion and created unnecessary difficulties in the building up and maintaining of proper records of the Municipalities' equities in the various systems.

THIRD—At this time, when the Commission was seeking a more satisfactory basis for the collection of sinking funds, the Ontario Government had under consideration the creation of a plan whereby it could retire annually a definite portion of its debt. This was in 1925 and at that time the Hydro debt to the Province amounted to $132,000,000, or a little over 40 per cent. of the Province's debt. In view of the fact that so large a portion of the Province's debt represented funds advanced to the Commission it was necessary for the Government to have the co-operation of the Commission in deciding upon a mutually satisfactory period and programme for debt retirement.

Without going into the details of the deliberations of the special Government committee appointed to study the debt situation and report upon a workable plan, it is sufficient to say that in its report to the

Government in March, 1926, it was recommended that the sinking fund periods of the Commission be on a uniform basis of forty years using an interest rate of 4 per cent.; and it was further recommended that the Power Commission Act be amended in order that the Commission's recommendations with regard to the retirement of the "Hydro" debt might be carried out. An essential provision of this plan, in so far as it relates to the Commission's debt to the Province, is that the Commission pays to the Government yearly—in cash—the required sinking fund instalments.

In connection with the new programme, the Government Committee and the Commission prepared debt schedules showing how the Commission's debt of $132,000,000 as at October, 1925, could be retired under the recommended plan.

The Government's schedule of the actual instalments required to be paid by the Commission over a forty year period commences in 1927 and ends in 1966.

In view of the fact that the Commission had been collecting sinking funds some years prior to 1925, its sinking fund collections, through the operation of compound interest, will, throughout the greater part of this period, (1927-1966) be in excess of the instalments required to be paid under the Government's plan. The sinking funds not utilized in the debt retirement in this period, have been, and will continue to be, invested in Provincial bonds and held against the later years when the sinking fund collections of the Commission will fall off due to the fact that some of its forty year retirement periods had commenced in various years prior to 1925.

Therefore, in making cash payments to the Province subsequent to 1959 and up to the year 1966, the cash required in excess of the Commission's sinking fund collections in those years will be met by liquidating the securities above referred to, with the result that in 1966 the total capital obligations of the Commission, amounting to $132,000,000—as they stood at October 31, 1925, when the new Government plan became effective—will be completely discharged.

With respect to capital advances subsequent to 1925, all the sinking funds collected by the Commission are being turned over to the Government *in cash*, according to the provisions of the debt retirement plan.

These payments are credited to the Commission by the Government in a special "re-payment" account, and interest is paid thereon by the Government to the Commission half-yearly at the current rates used by the Government in calculating interest on the advances it makes each year to the Commission.

Inasmuch as the Commission continues to pay interest to the Government upon the *total* advances and the Government, in turn, pays the Commission interest at current prevailing rates upon its sinking fund deposits, it will be appreciated that there is no difference in the ultimate results in so far as the Commission is concerned as compared with the arrangements when all the sinking funds were invested in Provincial securities.

The present plan of making yearly

cash payments in respect of the Commission's sinking fund instalments rather than investing these funds in bonds has the further advantage of relieving the Commission of considerable responsibility, and a large expense incidental to the purchase, recording and supervising of what would be a rapidly increasing volume of trust fund securities.

As regards the retirement of the capital represented by the Commission's debt to the Province through the operation of the sinking fund, it will be appreciated that this can be accomplished and given effect to in the cost of power service only in annual steps commencing in the 41st year from the time sinking fund was first levied in the cost of power. For instance, in the year 1912 the Commission collected sinking fund on a very nominal amount of capital (approximately $300,000). This amount of capital, which will have been paid up in the year 1951, will, in the annual adjustment of the cost of power for the year 1952, be credited to the municipalities which created the equity.

This procedure followed throughout the succeeding years will result in the gradual retirement of the Commission's capital liability and, consequently eventuate in a corresponding relief to the municipalities in respect of sinking fund and interest charges.

In the case of capital expenditures for ordinary extensions and enlargements to the existing works, provision for sinking fund commences as from the date these works are placed in operation; but as regards major expenditures for works acquired or new works, the construction of which might extend over a period of a year or more, the provisions of the following section of the Power Commission Act govern:

> "The Lieutenant-Governor in Council may authorize the Commission to postpone the collection or setting apart of any sums on sinking fund account to provide for the cost of any works newly constructed or acquired or performed for such period, not exceeding ten years as may be deemed advisable."

The actual amount of sinking fund payable by each of the municipalities, rural power districts and other power customers is ascertained following the allocation of capital in the annual adjustment of power costs, the calculation being made thereon at the rate of 1.053 per cent. per annum, which is the equivalent of a 40 year 4 per cent. basis.

The sinking fund collections thus ascertained are credited annually to each municipality and rural power district, together with a proportionate share of the sinking fund similarly determined as having been provided from the revenue received from private companies. In this way there is being accumulated by the municipalities operating under cost contracts a growing equity in the power systems.

A detailed record of each municipality's equity is thus maintained, a summary of which is published in the Commission's Annual Reports and reflected in the books and balance sheets of the Hydro utilities.

Interest earnings on sinking fund in excess of 4 per cent. are credited to the municipalities and rural power

districts in the annual adjustment of power costs in proportion to the amounts standing, respectively, to their credit on sinking fund account.

REVENUE—SOME ASPECTS OF ITS DETAILED EMPLOYMENT

As you know, the Commission's only source of revenue is that received from the power service supplied to the municipalities, to rural power districts and to other customers. This revenue is required in part to meet the current operating, maintenance and administrative expenses of the Commission, and to provide for the periodically recurring interest payments in respect of capital liabilities. The amount of revenue in excess of these classes of expense represents collections on account of sinking fund, renewals and contingency reserves.

It has been pointed out that the larger part of the Commission's outlay for interest is payable to the Province. These payments are made semi-annually—April and October—whereas the interest in respect of the Commission's bond issues falls due and is payable from time to time throughout the year. In addition to the interest on advances, the Commission pays to the Province annually on October 31st, the major portion of the sinking funds collected as part of the power service. These payments are in accordance with the provisions of The Power Commission Act and conform to the Debt Retirement Plan of the Province.

During the periods between the dates of payment to the Province of interest and sinking funds, these moneys are employed to finance the Commission's expenditures on capital account, to the extent of the demands made upon them on account of new construction. Such use of these funds does not relieve the capital accounts of the proper charge for interest during the construction period. Interest is charged at current rates to all works during the period of construction and until such times as the properties are placed in operation. The interest earnings resulting from this temporary employment of the Commission's current receipts is applied in reduction of the amount of interest which would otherwise be included in the cost of power service.

As has been stated, that part of the revenue in excess of the above-mentioned current and accruing expenses represents collections in respect of renewals and contingency reserves, and, except for the amount which is continually required for working capital, is currently invested in government bonds. All such securities are deposited in the Commission's vaults, earmarked for the specific purposes for which the funds are being set aside. Interest earnings in respect of these investments in excess of 4 per cent. per annum are also applied in the reduction of the amount of interest which would otherwise be chargeable as part of the cost of power service.

If after making the necessary investments in respect of reserves and providing for the current capital expenditures it is found that funds are accumulating more rapidly than is necessary for these purposes, two courses may be followed.

If the amounts are relatively small they are transferred to the savings

account, but when they are of substantial amounts it is usually possible to deposit these with the Provincial Government by subscribing to a treasury bill payable on demand, and with an interest yield which accords with the current prevailing bond rates. Such transactions are advantageous because they can be put through without expense to the Commission. When it is not possible to make such arrangements with the Treasury Department the Commission would temporarily invest in provincial bonds.

The interest earned on any such investment in treasury bills is also applied in reduction of the amount of interest which would otherwise be chargeable as part of the power service.

The methods outlined above to keep such current funds employed obtain throughout the periods between interest and sinking fund payment dates. At these times—April and October—any treasury bills of the Government which the Commission may hold are paid, and concurrently the Commission makes requisition upon the Government for all moneys expended on capital account from current revenue between these periods of the fiscal year. Upon receipt of the Government's cheques liquidating any treasury bills and covering the amount of the Commission's requisition, the Commission, having been thereby fully reimbursed, is in a position to meet its obligations to the Government in respect of interest and sinking fund.

Before closing, it might be of interest to refer to the subject of working capital, particularly as regards the funds required to carry the Accounts Receivable from the municipalities and other power customers.

As has been stated, the Commission has no source of revenue from which to draw its working capital other than the receipts from the sale of power. The greater portion of the Commission's revenue being required to meet current and accruing expenses, leaves only the collections in respect of renewals and contingency reserves from which to draw the necessary funds for this purpose. Inasmuch, therefore, as the working funds are obtained from the reserves —and these are being collected on a basis of rates requiring interest improvement — the interest on the amount employed for working capital is provided for in the interest charges forming part of the cost of power service, in accordance with the provisions of Section 56 B of the Power Commission Act.

That is to say, the Commission's reserves are improved at a fixed rate of 4 per cent. per annum, whether these funds are invested in securities or employed as working capital.

The period of grace allowed by the Commission for the settlement of these accounts is applied alike to all municipalities. The interest accruing to that part of the reserves used for working purposes during this period is taken up in the cost of power and provided for on an equitable and common basis. When, however, the period allowed for payment is exceeded, the Commission must, necessarily, make a charge for interest, because if such a policy were not in force those municipalities paying promptly would be assuming more than their equitable share of the

interest applicable to working capital.

The interest collections from municipalities and from other power users in respect of overdue accounts are applied in the reduction of the amount of interest chargeable in the annual adjustments as part of the cost of power.

Lightning's Freaks

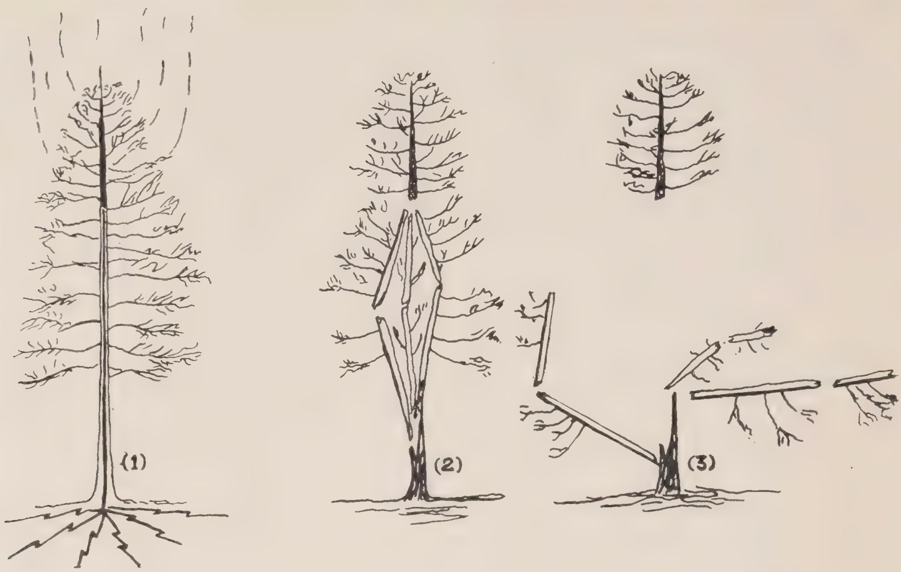
The vagaries of lightning are always interesting and the accompanying photograph and sketches show a very unusual result where lightning struck a white pine tree in the Humber Valley, near Bolton, during a very severe storm on August 14th.

This tree was about eighty feet tall and stood amongst elm, beech and cedar trees of much less height. The first mark of the lighting was at a point about thirty feet from the top of the tree, the entire crown being apparently undamaged. Below this point, the complete trunk was exploded by the stroke passing down its centre, the long splintered sections having been thrown in different directions and found lying in positions radial from the stump.

With the exploding of the trunk, the whole crown of the tree had been left in mid-air, without support, and fell vertically downwards, missing the stump by only a foot, and being found, as shown, lying on top of some of the large splintered sections of the exploded trunk which had reached the ground before it.

The sketches show the manner in which the trunk exploded and the crown fell, according to the evidence remaining, and the case again confirms

White pine tree after having been struck by lightning.



Sketch showing how the trunk exploded and the crown fell.

the rule that "lightning will not strike twice in the same place",— for the place itself has disappeared.—*F.K.D.*

Nodules

By A. E. Davison, Transmission Engineer, Electrical Engineering Dept., H.E.P.C. of Ont.

"TEN-YEAR old boy's Paradise" should be the name of a brook or a farm where naturally made perfectly round marbles can be picked up. The small boy on that farm can afford to be a good loser because he can go back and fill his pockets whenever he pleases. There will always be a bear market for marbles in Gloucester Twp., Carleton County, Ontario.

While excavating for tower foundations for the new Beauharnois-Chats Falls, 220-kv. line in the clay flats near Mere Bleu, south-east of Ottawa, pebbles, many of them, perfectly round so far as one can observe, were found in the clay at varying depths up to eight feet. Many of them are free in the clay and could be washed off revealing a quite smooth surface. There was little cementing of one pebble to the other. Roughened surfaces and adhering irregular masses were exceptional. Many were found along the nearby creek having been washed out of the clay bank while the creek was cutting an irregular channel, of varying depths up to fifteen to twenty feet, through the clay flats.

Throughout nature there is the occasional pebble, hand-stone, or even boulder that is round or nearly so. Then there are the churning stones found in the "pot-holes" along the rapids of the Niagara River, where small irregular stones are caught in a depression in the bed rock under fast moving water. The stone is churned about, wearing more and more spherical if it is of uniform hardness. In some cases pot-holes are worn more than two or three diameters in depth, possibly by a second or several relatively hard stones, working either at one time or successively in one pothole.

The "kettles" at Kettle Point on Lake Huron have a closer relation with these concretions and are another quite interesting type of deposition. It would appear, however, that they are alike only in minor respects.

Nearly perfect spheres of naturally formed concretions excavated from clay beds east of Ottawa, Ontario, at depths up to five feet while building 220-kv. "Beauchats" lines. Note the effect in the shadows—an interesting photographic study.

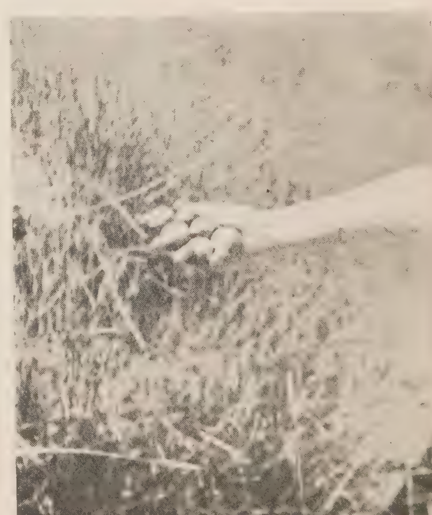
Bed of Spring Creek near Blackburn showing group of "Nodules" in natural position. Some of these are quite round.

The kettles are true concretions, are round but relatively much larger. Why they are called kettles is not clear to some. They, in some cases, may have a soft centre which has been washed out. The marbles seem to have resisted any hollowing out process even if the centres should happen to be softer than the outer portions.

Along the shores of Lake Superior the quite hard agate pebbles (an article of commerce, being used in "pebble" and "ball" mills for grinding cement) are sometimes found quite round.

The profusion in which these spherical hard pebbles occur naturally, near Ottawa, is however quite unique. These concretions are not always round. For instance, along the Ottawa River about 8 miles east of Ottawa many concretions of this type are found, however, they are not usually spherical. "Nodules" seem to be the most descriptive word excepting to the small boy, who will always call them marbles.

The nodules appear to be gray clay hardened and cemented by magnesium or other salts. They have about the same colour and appearance as the clay-beds in which they are found and from which they have been eroded. Some of these nodules are quite resilient and are difficult to crack open with a hammer, others are relatively soft and can be scraped away and almost whittled with a knife. If magnesium predominates they may be expected to be quite hard. Inside the colour varies fairly uniformly toward the centre where there is usually a quite dark gray area about



"Nodules" picked up from eroded bank of Spring Creek, Gloucester Township, Carleton County, Ontario.

Pot holes found in the bed of Niagara River above Niagara Falls when unwatered a number of years ago by the Toronto-Niagara Power Company. Three pot holes can be seen at the left of the picture. A stone and some sediment can be seen in one of them. Another stone that has been working similarly can be seen in the crevice in the right of the picture.

¼ inch in diameter. A nucelus of foreign matter seems in most cases to be essential. Some nodules have a little coarse sand as a nucelus, some have shells, etc. Even grass blades have been found at the centre.

The geologists have for a number of years known of these special depositions and are quite interested. They have outlined several theories regarding the uniformity and the occurrence of these nearly perfect rock spheres. Dr. M. E. Wilson of the Geological Surveys, Ottawa, discussing depositions of this type generally in G.S.C. Memoir 39, says—

"—It is improbable that there is much free circulation of water in these impermeable clays, so that when the soil becomes dry during seasons of drought and the ground water level passes downward, the carbonate of lime is redeposited. This deposition having once commenced at a given point tends to continue at that point and in this way a concretion is built up. The peculiar symmetry of the resulting forms can scarcely be accidental and may be related as suggested by Todd to the process by which additions of material take place in crystal growth."

Mr. Todd who is quoted by Dr. Wilson, writing in Bull. G.S. of A., Vol. 14, curiously enough, makes use of electric current to explain some of these depositions, when he says—

"Concretions are stones that grow, or, in other words, are

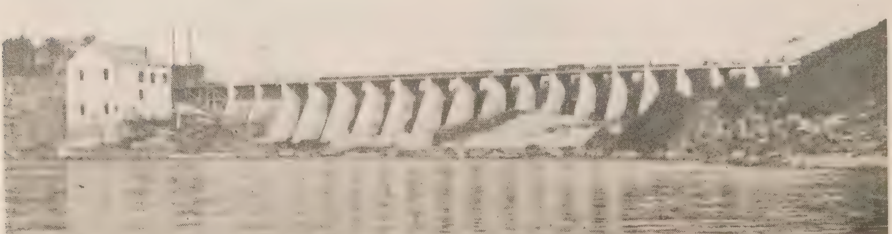
nodular growths of various minerals sparsely distributed through the country rocks. They vary greatly in size, shape, composition, distribution and method of growth.

"Concretions differ from stalactites, either pendant or coralloidal, which are formed in the former case by trickling water, and in the latter case by oozing water; they also differ from stalagmites which result from dropping water; and from other forms of cave deposits, as these are all found with free surfaces and not embedded, as is always the case with concretions. Moreover, though all grow mainly by additions to the outside, like concretions, and though portions of them may resemble concretions in form, yet they are always attached by a base to country rock, which is never true of concretions.

"Crystals are the normal form which minerals take when solidifying from solution or fusion without the interference of surrounding material or contact with each other. Concretions result when the embedding rock prevents the orderly arrangement of the molecules, though they may still cohere in an irregular way—

"The force conceived to bring together molecules into either crystals or concretions is a form of molecular attraction, influenced perhaps, sometimes, by electrical relations. This attraction withdraws molecules from the mother liquor in the immediate vicinity of the crystal and builds them into its structure. This impoverishes the solution in contact, and consequently diffusion takes place from the saturated solution farther away to enrich it. As these processes continue, quasi-currents of molecules similar in nature to those of the crystal converge toward it from all directions and from an indefinite distance. It is not necessary to postulate motion of the liquid which acts as a vehicle, though motion of such medium may sometimes accelerate or otherwise influence the growth of both crystals and concretions. The impoverishing of the surrounding rock in the vicinity of concretions is often conspicuously indicated by a difference of colour."

The photographs show some of the nodules lying exposed in the clay bank of a small creek near Blackburn. Others show them as true spheres with shadow effects, attractive at least to the marble Midas.



Electrical and Hydraulic Tests at the Chats Falls Development

By G. D. Floyd, Testing Engin eer, H.E.P.C. of Ont. Laboratories and J. J. Trail, M.E..I.C., Engineer of Tests, Hydraulic Dept H.E.P.C. of Ont.

(Paper presented at the General Professional Meeting of the Engineering Institute of Canada, Ottawa, Ont., February 8, 1933.)

THE electrical and hydraulic tests described in this paper are those having interest because of the methods applied to solve the particular problem in each case, or for some other reason that will be evident. It is not considered necessary to describe the development, as that has been done in other papers. Descriptions, therefore, are limited to parts under test or test equipment.

ELECTRICAL TESTS

Tests made in the field on the electrical equipment were of two kinds:—

(1) Those necessary to check the correctness and insulation of wiring and the adjustment of equipment that had been erected in the field.

(2) Those made on the generators to determine if guarantees had been met, and whether the generators were, in fact, as required by the specifications covering them.

A detailed description of the tests made is beyond the scope of this paper, so only those which are considered to have some special interest will be discussed.

Tests made under the first group included: high potential test (momentarily) at 39 kv., on coil groups of stator windings; checking of all control wiring and high potential test on control and power cable; checking and adjustment of all relays and associated current transformers before placing in service, adjustment and test of low voltage and high voltage circuit breakers.

Each main transformer bank received a test run on short circuit for twenty-four hours with transformer oil at 75 degrees C. to release entrapped air in the oil. As it was estimated that the transformer oil would not reach 75 degrees C. with full load current from one generator, two generators were used, paralleled on the low voltage bus. It was found possible to synchronize the generators, by closing them in together on the transformer bank with no excitation, bringing up the fields on each together, and finally making slight adjustment of speed on the units until they pulled in step.

TESTS OF PROTECTIVE RELAYS

Tests were made on line relays by closing in on a metallic short circuit at 220 kv. through 200 miles of line. After relays had been adjusted, a further test was made by closing in on a three-phase short circuit on the Chats Falls high voltage bus, made by placing a 3-ampere fuse across a section of 220-kv. bus, and clearing the fault by relay operation. The latter test was made with the system in normal operation, and checked the selectivity of all relays in the station,

as well as the time required by the high voltage circuit breakers to clear faults.

Measurement of Station Ground Resistance

As very special attention had been given to the design of an adequate station ground, and as the facilities for the establishment of this ground were very poor, due to the rocky nature of the site, tests were made to determine station ground resistance. Initially, tests had been made to determine ground conductivity, and to assist in the selection of a suitable location for the ground plates. After the latter had been established, and the grounding system completed, a test by the volt-ammeter method was made, using a telephone lead fifteen miles long to a point of neutral ground potential. The station ground resistance was 1.05 ohms as measured. Potential gradients around the station were measured as well, so as to assist in the proper location of isolating transformers for communication and other circuits extending beyond the area of the station grounding system.

Generator Acceptance Tests

The tests made on the generators, except high potential tests which were made before each generator was placed in service, were all made after erection of the eight units had been practically completed. The specifications called for complete tests to be made on each unit, but this was not adhered to. Only those tests were made on each unit considered necessary to establish whether all generators could be reasonably assumed to have similar electrical characteristics.

A schedule of tests was drawn up, fitting the tests into the erection schedule on the second four units and arranging it so that the electrical and turbine tests would not conflict. Arrangements were also necessary so that operation could be carried on without interruption, and the requirements of the power contract met.

Tests Made on All Generators

Tests made on all generators were:—

Cold resistance, stator and field windings.

Open circuit and short circuit saturation.

Insulation test, stator and field.

Check on open circuit saturation, main and auxiliary exciters.

Test and adjustment of voltage regulators.

Check on phase rotation.

Overspeed test (with one exception).

No departure from standard methods of test occurred in any of the above tests, except possibly in the measurement of cold resistance. For this test, a 6-volt battery and low range voltmeter were used, and considerable time saved in the measurement. Results were consistent, and there appears to be no reason why this method should not be used generally, if proper care be taken. However, if the cold resistance measurements are to be used for the determination of temperature rise of a winding on heat run, the same meters should be used for determination of both cold and hot resistances, which prevents the use of low range instruments.

The overspeed test was limited to 1.7 times rated speed, and voltage was built up to 23 kv. on the generator while operating at overspeed, and held at this value for one minute. A curve of gate opening/speed indicated that the maximum speed of the units would occur at 10/10 gate, and would be approximately 221 r.p.m. at normal head.

One generator only received a sudden short circuit test at normal voltage, and the insulation test on its windings was made immediately following the short circuit and overspeed tests.

Tests Made on One Generator Only

Tests made on one generator only were:—

Heat run.

Measurement of core loss, windage and friction, load loss.

Zero power factor saturation.

Sudden short circuit test.

Measurement of voltage response of main exciter.

Test to determine sensitivity of split phase relay protection.

Two heat runs were made with commercial load, one at rated load current, the other at 1.1 times rated current, the kilowatt load being the same for both tests. The duration of each test was until constant temperatures of windings and core iron were reached.

Measurement of Losses

Losses were measured by the retardation method. One generator was disconnected from its turbine, and was driven by another generator. The excitation for both was supplied by the main exciter of a third unit, this being necessary so that the unit under test could be started from rest. After the initial start, a great deal of time was saved by synchronizing the generator under test with its driving generator, as the former decelerated through the fixed speed of the latter. This was done by lowering the speed of the driving generator to 10 per cent. below normal immediately after the two generators had been separated electrically. At about 8 per cent. below rated speed on the generator under test, fields were opened on both, and the main circuit breaker closed, followed immediately by closure of both field breakers. As the field currents built up, the generators synchronized quickly, after which speed was raised, and another retardation test made.

Accurate measurement of speed is absolutely essential on this test. A chronograph was used which records the number of revolutions made by the generator during a short time interval, which is also accurately determined. The average r.p.m. for the interval can thus be determined. The possibility of using the auxiliary exciter (separately excited) as a tachometer was also investigated, and it was found that, if reasonable care be taken, the exciter can be so used. As chronographs are not usually available, the fact that the auxiliary exciter, or its equivalent, can be used for speed determination is worth noting. The computations from the chronograph records are also tedious, so that the direct measurement saves time, with little or no sacrifice in accuracy.

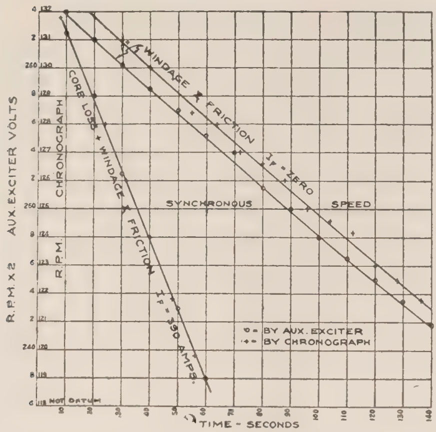


Fig. 1—Typical Retardation Curves.

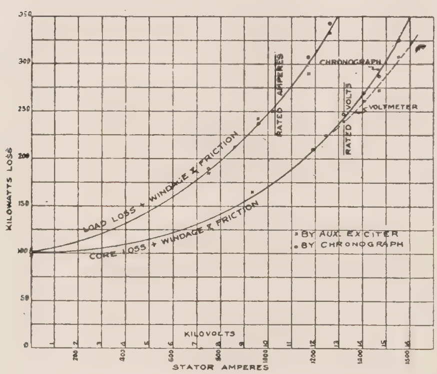


Fig. 2—Generator Losses Determined from Retardation Tests.

Fig. 1 shows typical retardation curves, and Fig. 2 the losses as determined by each method.

The zero power factor saturation curve was taken immediately following the measurement of losses. It is usually impossible to circulate full load current at zero power factor between two hydraulic generators of conventional design, because of the relatively high synchronous impedance. No difficulty was experienced in this case, however, as these units have relatively high short circuit ratio (1.34).

Fig. 3 shows the oscillograph record taken on the sudden short circuit test. The transient and sub-transient reactances, as determined from this record, agreed closely with design figures.

As special provision had been made in the specifications covering these generators to obtain a unit with quick response excitation, a number of tests were made on the excitation system of one generator to determine if the response was in fact as the designer had predicted. Fig. 4 is a typical record, and Fig. 5 shows data taken

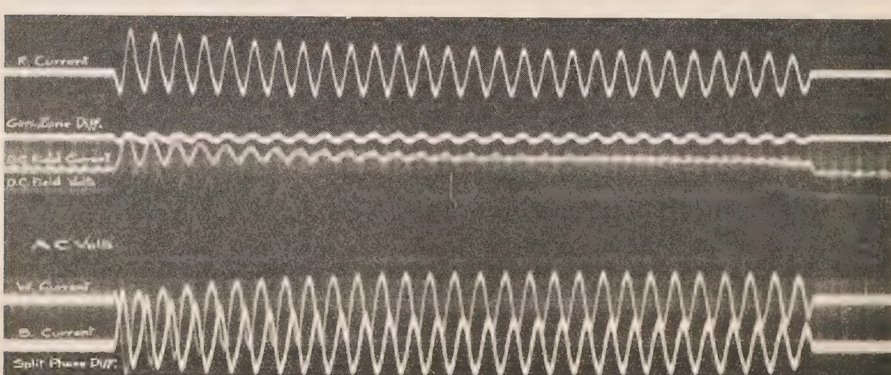


Fig. 3—Record from Sudden Short Circuit Test at Rated Voltage.

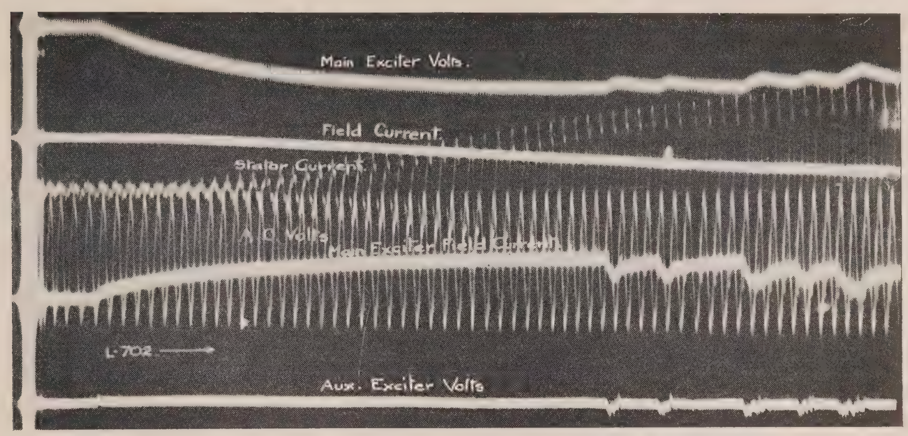


Fig. 4—Record from Test of Excitation Response.

from several such records compared with a curve of voltage response submitted by the manufacturer before the generators were built.

The test on the split phase relay protection was made to determine if this relay would operate if one coil of the stator winding at the neutral end was short circuited. Temporary leads were brought out from one coil at the neutral end to an oil circuit breaker, which was closed and opened manually. The tests were made at reduced voltage to limit the short circuit current to a safe value. Fig. 6 is an oscillogram taken on these tests. The tests indicated that this protection was very sensitive. Relays on one of the sound phases operated as well, due presumably to magnetic coupling between phases causing a circulating current in the sound phase.

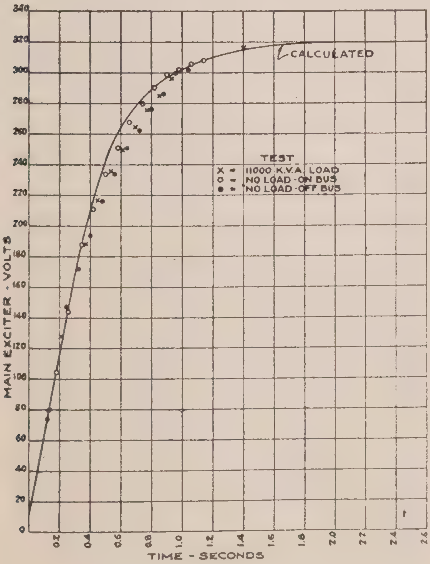


Fig. 5—Voltage Response of Main Exciter.

Observations made during tests at this and other generating stations indicate the desirability of always conducting as thorough tests as can reasonably be made before a station is turned over for final operation. There are always some defects that can best be remedied when discovered in this manner. The data obtained are often invaluable, both to manufacturers' and utilities' engineers.

The advisability of careful planning beforehand where an extensive series

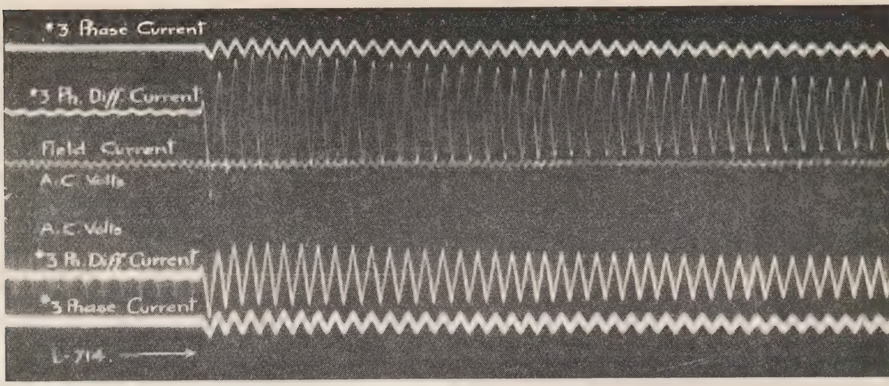


Fig. 6—Record from Test on Split Phase Relay Protection.

of tests is to be made was well demonstrated during the generator tests at this station. The schedule as laid out could have been met in no other way, and its completion proved that in this, as in other engineering work, the closest co-operation between various departments—operating, erection and testing—was essential to whatever results were accomplished.

Hydraulic Equipment

The turbines at the Chats Falls development are eight in number, of the fixed blade propeller type, rated at 28,000 h.p., 125 r.p.m., 53-foot head, specific speed 140. Each receives its water supply through three intakes, 15 feet wide, and 23 feet to 20 feet high, which unite 28.25 feet downstream from the headgates to form a single rectangular channel which is the beginning of the transition to the scroll case. The guide vanes are twenty in number, 7.33 feet high and have a clear opening at full gate between successive vanes of 22.53 inches. The turbine runner is 16 feet 2½ inches in diameter; the upper edge of the vanes is at elevation 190.25, and the lower edge at elevation 186.25. As minimum tailwater is at elevation 189.0, it will be seen that the turbine runner is at all times partly or completely below tailwater level.

Hydraulic Tests

The hydraulic tests had as their objective the determination of the characteristics of the turbines, and the determination of their capacity, efficiency and water economy. The discharge of one turbine at full gate is about 6,000 cubic feet per second. Methods of measuring this discharge for the purpose of rating the turbines were considered during the progress of the design of the plant. The supply channels are probably shorter than any others upon which measurements have been attempted by means of the Gibson time-pressure method, but, as very satisfactory and consistent measurements had been made using this method on turbines at the Alexander power development, the decision was reached to apply it also at Chats Falls.

At the Alexander power development the supply pipes are two in number, 30 feet long, 18 feet wide, and 19 feet to 12 feet high. Gibson instrument taps, installed for a differential test, were 22 feet apart. Tests were made on three units, and were unusually consistent with each other and with results derived from model tests, in spite of the restrictions imposed by the length of the supply pipes. Although the available distance between taps was less at Chats Falls than at Alexander, it was considered that the Gibson method possessed certain advantages over other methods that warranted its application in this case.

Accordingly, provision was made for the tests by erecting in the concrete around both upper and lower ends of each of the three water passages, a ring of piping with outlets into sides, top and bottom of the passage. Connections from these were carried to outlets on the power house floor at points convenient for placing Gibson instruments. The distance between upstream and downstream outlets was 18 feet. Fig. 7 shows the piping system for the Gibson tests.

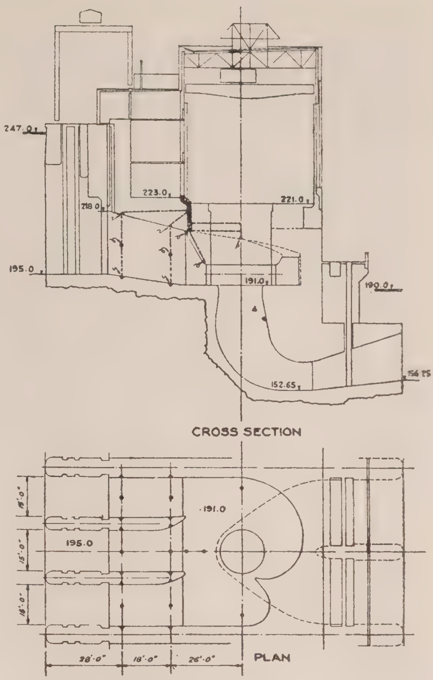


Fig. 7.—Piezometer Opening and Piping for Gibson Tests.

The Gibson Time-Pressure Method

Only the briefest explanation of the Gibson time-pressure method of measuring water may be given here. The method is one of the few that are rigidly correct in principle. It is based on Newton's second law of motion, namely: "Change in momentum is proportional to the impressed force. . . . ," or, as usually expressed in dynamical units, $Pt = m\ (v - u)$.

To effect a discharge measurement in the case of a turbine test, the turbine gates are closed in suitable time, and the pressure changes resulting during the period of closure, as indicated by the movement of a mercury column, are photographed on a moving film. The diagram on the film has time as its horizontal, and force as its vertical scale. Analysis of the record on the film permits the measurement of an area which is proportional to the product of P and t in the above formula. Measurements of the supply pipe give the information from which the mass of water brought to rest may be calculated, and the remaining quantity $(v - u)$, the reduction in velocity in the supply pipe, may then be determined by solution of the

equation. The velocity v is that at the time at which the turbine gates commence to move, and u the velocity at the end of their movement, or the velocity corresponding to turbine gate leakage. If the leakage of the turbine gates when closed is determined, the total flow at the time the gates commence to move is known.

In practice, the connections to the Gibson taps in the supply pipes are led to a U-tube, on one side of which is a calibrated glass tube, and on the other a steel tube of uniform diameter, much larger than the glass tube. The glass tube, with mercury in it, is fixed in front of a slot in the camera, in which the record film is placed, and light cannot pass through that part of the tube filled with mercury. As pressure changes take place in the supply pipes, the mercury moves up and down, its movement being directly proportional to the change in pressure, and the record on the moving film thus records the changes in pressure.

Test Procedure

It was anticipated that the discharge would be different in different supply pipes, and, in any event, it was considered essential that separate measurements of flow should be made in each passage. Three Gibson instruments, therefore, were used. The restricted length available between the Gibson taps and the low velocities in the supply channels introduced a difficulty that was experienced in a minor degree in the Alexander power development tests, namely, that the area of the pressure-time diagram would normally be very small. It was attempted to obtain a larger diagram by substituting acetylene-tetrabromide for mercury. This liquid has a specific gravity of 2.94 and may be coloured red to prevent the passage of light rays of high actinic

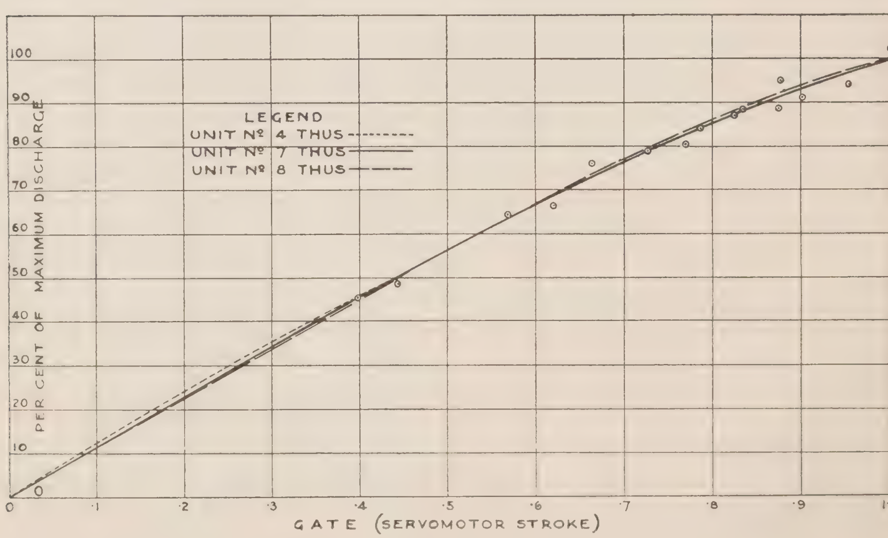


Fig. 8—Gate Discharge Relations.

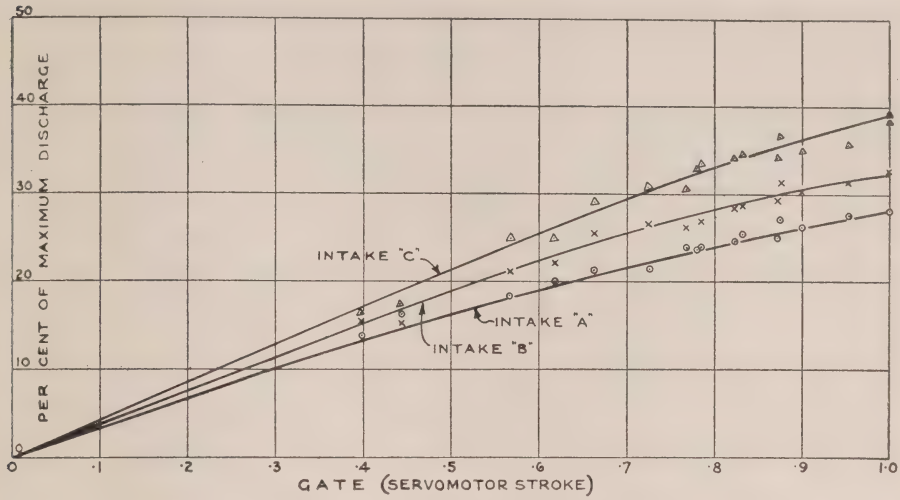


Fig. 9—Distribution of Discharge Between Supply Pipes.

power. A number of tests were made using this liquid, and compared with similar tests in which mercury was used. The results were the same in both tests, and, as the acetylene-tetrabromide gave difficulty on account of its mobility, and as it tended to form an emulsion at the plane of contact with the water, thus resulting in an indefinite boundary to the pressure-time diagram, mercury was used in all succeeding tests. The results obtained warrant further investigations with this liquid, however.

It is possible, in most cases, to determine the instant of closure of the turbine gates from the Gibson diagram itself with considerable accuracy, but methods ordinarily applicable were not satisfactory in this instance. Special auxiliary shutters were therefore installed in the cameras and operated electrically. A contact was fixed on the servomotor piston rod, which closed the shutter circuit and opened the shutter when the servomotor piston reached the end of its stroke. The light passing through the aperture, controlled by the auxiliary shutter, drew a line at the bottom of the diagram, the beginning of which marked the end of movement of the turbine gates. This, along with the time-stroke diagram of the servomotor movement recorded by a chart-drawing instrument, gave information from which the beginning and end of the pressure-time area were determined accurately.

Readings of headwater and tailwater were taken on five float gauges installed in stilling boxes. Power measurements were made by a calibrated watthour meter and a portable wattmeter, and sufficient additional readings were taken on portable instruments to permit generator losses to be computed for each run. All portable meters were calibrated in the laboratory.

Results of Hydraulic Tests

Figs. 8, 9 and 10 illustrate some of the results of the hydraulic tests.

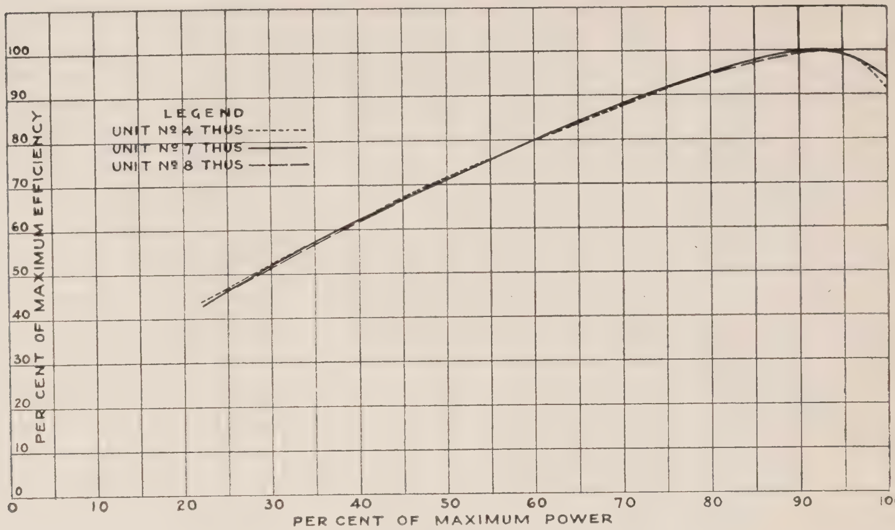


Fig. 10—Power Efficiency Relations.

Unusual consistency in measurement of discharge was obtained. Fig. 8, giving the relation between gate opening and discharge for three units, illustrates this. In plotting the results on this and Fig. 9, the observed results have been corrected for head, and these corrected figures have been divided by the discharge of unit No. 7 at full gate to obtain the percentage of maximum discharge. The discharge curves for different units were plotted independently on separate sheets, and the combination of these three separate plots used to make up Fig. 8. The correspondence of the separate results is remarkable. For all practical purposes, a single discharge curve might be used.

The correspondence of the individual discharge measurements with the mean curve for unit No. 7 is shown by the plotted points on Fig. 8, which are all for this unit.

The variation in discharge between supply pipes is shown in Fig. 9. The results here are for unit No. 7. The other units show about the same distribution of discharge between supply pipes. All percentages in Fig. 9 are based on the discharge of unit No. 7 at full gate.

The efficiency curves shown in Fig. 10 exhibit the same consistency as the discharge measurements. Power measurements have not been shown, but these also are very con-consistent. The efficiency is well sustained at part gate for units of as high specific speed as these.

The writers regret that they are not at liberty at this time to give actual results for efficiency, power and discharge, as final agreement on all tests has not been reached.

Association of Municipal Electrical Utilities

Minutes of Executive Committee Meeting

A meeting of the Executive Committee of the Association of Municipal Electrical Utilities was held at the office of the Hydro-Electric Power Commission of Ontario, Toronto, on the afternoon of Monday, October 16th, 1933. Those present were—Messrs. T. W. Brackinreid, Chairman, E. V. Buchanan, R. S. Reynolds, G. E. Chase, M. W. Rogers, O. H. Scott, W. R. Catton, C. E. Schwenger, R. S. King, D. J. McAuley and S. R. A. Clement, and Mr. C. A. Maguire, President, and Mr. T. J. Hannigan, Secretary, Ontario Municipal Electric Association.

It was moved by Mr. E. V. Buchanan and seconded by Mr. O. H. Scott THAT the Minutes of the Executive Committee meeting of April 18th, 1933, and of the Convention at Windsor of June 22nd, 23rd, and 24th, 1933, be taken as read and adopted.—*Carried.*

The Secretary read correspondence as follows:—

A letter from O. M. Perry, Windsor, attached a letter from H. Whorlow Bull, Conductor of The Border Scottish Choir, expressing appreciation for the manner in which the Associations showed their regard for the musical programme presented on June 22nd.

A letter from R. E. Garrett, Sarnia, suggested separate sessions at conventions for engineering and accounting discussions.

Letters from the manager of the Royal Connaught Hotel, Hamilton, and F. P. Healey, Secretary Convention Bureau, The Hamilton Chamber of Commerce, suggested Hamilton for the coming winter convention, or possibly an early summer convention.

A letter from Charles O. Shaw, President, Bigwin Inn, asked the privilege of having a representative attend when the meeting place for next summer convention is chosen.

Letters from the King Edward Hotel, Toronto, bid for the convention to be held this winter.

A letter from W. J. Robertson, National Stationers Limited, Toronto, expressed the desire of his company to become a Commercial member. It was moved by Mr. E. V. Buchanan and seconded by Mr. G. E. Chase THAT National Stationers Limited be elected a Commercial member. —*Carried.*

The question of hotel headquarters for the winter convention was discussed at length. Reference was made to tentative reservations held by the Royal York Hotel for January 31st and February 1st, 1934, as recorded in the Minutes of the Executive Committee meeting of April 8th, 1933, but had not as yet been officially accepted.

It was moved by Mr. E. V. Buchanan and seconded by Mr. O. H. Scott THAT the Winter Convention be held at the King Edward Hotel, Toronto, on Wednesday and Thursday, January 31st and February 1st, 1934.—*Carried.*

The Secretary advised of having had conversations with the President of the Electric Club of Toronto, and that an invitation would be received by both the Ontario Municipal Electric Association and this Association to attend the Electric Club luncheon at the Royal York Hotel on January 31st, 1934. The Secretary was instructed to accept this invitation.

Mr. E. V. Buchanan, Chairman Papers Committee reported regarding suggested papers and discussions for the Convention, as follows:—

A Paper on the future use of Electric Power, by W. P. Dobson, Chief Testing Engineer, Hydro-Electric Power Commission of Ontario.

A Paper "Better Light—Better Sight", by George C. Cousins, Testing Engineer in Charge, Illumination Laboratory, Hydro Electric Power Commission of Ontario.

A Paper "The Story of Copper", by W. C. Burch, Toronto Hydro-Electric System.

A Paper on the use of current by domestic consumers.

A discussion of the water heater campaign.

A discussion of accounting subjects, arranged by the Committee on Accounting and Office Administration.

It was also suggested that prominence be given to a forthcoming report of the Merchandising Committee, more particularly in reference to Hydro Shops.

Mr. E. V. Buchanan moved the adoption of his report and THAT the Chairman of the Papers Committee, Mr. T. J. Hannigan, Mr. D. J. McAuley and Mr. S. R. A. Clement be a committee to arrange as to placing the various papers and discussions on the programme. This motion being seconded by Mr. R. S. King, was *Carried.*

Mr. W. R. Catton, Chairman Convention Committee, advised that his committee had not met to consider details of entertainment for the convention, but would do so in the near future. He asked for an appropriation for that purpose and it was moved by Mr. O. H. Scott, and seconded by Mr. R. S. Reynolds THAT the Convention Committee be made a Grant for entertainment during the convention of $250.00. —*Carried.*

The committee appointed to arrange the Convention programme was asked to keep the suggestions in Mr. Garrett's letter in mind in regard to the accounting session.

The Secretary was instructed to give Bigwin Inn and the Hamilton correspondents an opportunity for making representations to the Executive Committee, which will meet during the winter Convention to consider a place of meeting for the 1934 summer convention.

The meeting then adjourned.

THE
BULLETIN

Published by
HYDRO-ELECTRIC POWER COMMISSION
of Ontario

620 University Ave.
Toronto

Subscription Price $2.00
Per Year

Testimonal Banquet to Commissioner W. R. Woollatt, Walkerville

ON the evening of November 16, 1933, one of the happiest events in the annals of Hydro history was held in the form of a banquet given by the commissioners and employees of the Walkerville Hydro-Electric System at the Prince Edward Hotel, Windsor, in honour of Commissioner W. R. Woollatt to commemorate his completion of 20 years' continuous service as a member of the Walkerville Commission.

W. R. (Bill) Woollatt

Chairman of Walkerville Hydro-Electric Commission, to whom a banquet was tendered on his completion of 20 years continuous service as a commissioner.

Over 400 of the leaders of the commercial, financial, public and social life of the Border Cities and Essex County turned out to bear testimony of their faith and friendship in Mr. Woollatt and to pay tribute to him for his long service as a Hydro Commissioner.

The attendance surpassed the most sanguine expectations. Late arrivals were dined at specially arranged tables on the balcony.

All the local Hydro Commissions in Essex County were well represented by their commissioners and employees, together with officials from

CONTENTS

Vol. XX No. 11
Nov
DECEMBER, 1933

the Sarnia, Chatham, and St. Thomas Systems.

The Hydro-Electric Power Commission was fully represented by the Chairman, Hon. J. R. Cooke, Commissioners C. A. Maguire and the Rt. Honourable Arthur Meighen together with Chief Engineer Dr. F. A. Gaby, each expressing their high regard and appreciation for the able service rendered to the Hydro cause by Mr. Woollatt during his long term of office.

All three members of the Commission gave very illuminating addresses on the varied phases of the Hydro development which were keenly appreciated by the audience as a whole.

The O.M.E.A. was represented by its able Secretary Mr. T. J. Hannigan of Guelph and the A.M.E.U. by Vice-President W. R. Catton, Manager of the Brantford System.

D. B. McColl, General Manager of the Walkerville System in the capacity of toastmaster for the evening, presented Mr. Woollatt with a handsome travelling bag as a gift from his fellow commissioners and the members of the Walkerville Staff.

All of the speakers including the Mayors of the Border Municipalities, Mr. Hannigan and Ex-Mayor Harold R. Hatcher who was a fellow member on the Commission with Mr. Woollatt when it was first formed in the year 1914, extolled the virtues of Mr. Woollatt as a faithful worker for Hydro before and since the day of its advent in Walkerville and the Border Cities.

Mr. Woollatt who was humorously introduced by his fellow Commissioner, Mr. A. D. Green, with becoming modesty, disclaimed responsibility for any extraordinary accomplishments, giving credit to his colleagues and the System's staff in general, for the splendid progress made.

Mayor Farrow, the third member of the Walkerville Commission introduced the Rt. Honourable Arthur Meighen and Mr. O. M. Perry Manager of the Windsor Hydro-Electric System introduced Dr. F. A. Gaby.

The Walkerville System in particular and the Hydro System in general has been fortunate in having a man of Mr. Woollatt's accomplishments as a sponsor over such a long period of years.

"Bill" as he is known to his legion of friends in all walks of life typifies all that is essential in the make-up of a successful Hydro commissioner.

Through his many varied activities he has acquired a thorough understanding of the requirements of the general public, all of which knowledge

he has gladly given without compensation of any kind for the general benefit of Hydro.

He first became interested in Hydro affairs in the year 1912 at which time he became closely associated with the late Sir Adam Beck and the other members of the Ontario Commission in their efforts to extend the Hydro System to the Border Cities which was not accomplished until the year 1914.

Mr. Woollatt was born in Toronto on August 9, 1880, and moved to Walkerville with his parents when nine years of age. He was educated in the public and high schools of Walkerville and Windsor, later attending Western University at London.

He received his early business training under the supervision of his father the late Mr. Wm. W. Woollatt, one of Walkerville's most highly respected citizens while General Manager of the Lake Erie and Detroit River Railway, starting in a very junior position and later becoming agent for the Pere Marquette Railway at Port Stanley.

Subsequently he became connected with a steamship line running between Cleveland and Port Stanley, and later with the C.N. Railway at Fort William.

In 1905 he returned to Walkerville and with his father established the Wm. Woollatt and Sons Coal Business and later established a very successful automobile distributing business in the Border Cities which he continued to operate until the year 1921.

In addition to his many other activities he also acted as express agent for the C. N. Ry. at Walkerville for a period of 21 years.

His genial personality has endeared him to all members of the staff in each of whom he is keenly interested, constantly endeavouring to improve the working conditions on the system for the general benefit of both consumers and employees.

Mr. Woollatt has been active in masonic circles over a period of years, being the youngest master of a masonic lodge in Canada, so honoured when he was 25. He belongs to every branch of the organization, including the 33rd degree which he received in 1922. He is a Past Potentate of Mocha Temple, London.

In addition to being a member of the Walkerville Commission he is also a member of the Executive of the Ontario Municipal Electrical Association, President of the Canadian Greyhound Lines, President and General Manager of the Thorncliffe and Devonshire Race Tracks, President of the Keystone Construction Company, Windsor, and Vice-President of the Walsh Advertising Company, Windsor. He has few hobbies except work. He likes to play golf occasionally but according to himself is not particularly proficient at it.

Report of Commissioner C. A. Maguire's Address at W. R. Woollatt Testimonial Banquet

THE following report of Hydro Commissioner, C. A. Maguire's address at the Walkerville Hydro-Electric System's testimonial banquet to Commissioner W. R. Woollatt, is from the *Border Cities Star.*

"First," he said, "I want to compliment the chairman and his wonderful organization of Walkerville for bringing about this testimonial to a public servant.

"That is what made Hydro, the loyalty and inspiration of those who served it and is it not a splendid thing to pay tribute to one who has meant so much to the Hydro commission? The chairman and his associates deserve much credit for making it possible for us also to pay that tribute.

"Hydro to-day is optimistic, not pessimistic. And the presentation of a travelling bag to Bill Woollatt is an indication of the return of prosperity and it was for him to bring back the receipts of his activities.

"Let me say that we of the Ontario Hydro Commission felt that we would certainly be remiss in our duty if we did not attend this gathering and publicly express our appreciation of a public servant, known to you all as Bill Woollatt.

"I heard of Bill Woollatt long before I ever saw him. I heard it said that he was one who never touched anything until he was reasonably assured of its ultimate success. What an asset he is to Hydro.

"We of the commission are charged with the responsibility of furnishing power to the municipalities, and I well remember the early days when the going was not so easy or popular; when it was difficult to get speakers; when men admitted confidentially they were in favour of Hydro, but who said they could not take an active part for it.

"The days passed and they saw Hydro was not a mere fad, but a sincere effort, and they found the people could make a success of it if sincere co-operation continued and we have seen that. Can you look back and visualize when the first 100,000 horsepower was contracted for? It was not a question those days of making contracts.

"The first contract was from across the border to supply Ontario with power. And there was a thought then with some and often expressed that Ontario would be in a serious position before it could absorb the amount of power available in that day.

"But 13 municipalities banded together to get the power and to-day, I am happy to say, those 13 municipalities, confident in themselves and with a determination to serve the people and promote industry, have increased their number to 757 in this province. And not one of those municipalities wants to leave the family.

"We went on further. We journeyed to the government as an

organization and said, 'You should help the farmers to obtain light and power', and the government, without a moment's hesitation, said, 'Yes, we think you have a right to develop agriculture.' And the government subsidized the primary and secondary rural lines.

"I well recall the incident when President Roosevelt, then governor of New York, in an address said the time had come when urban New York State should be turning its face toward rural New York State in order that the farmers may get some benefit from electrical power.

"And I think we in Ontario were progressive and sympathetic when to-day there are 62,000 rural customers enjoying cheap light and power. That is what your commission is charged with; taking power to the uttermost parts of the province in order that the people may enjoy its benefits.

"I recall that our late chairman, Sir Adam Beck, realized we must secure more power by the development of the great Chippewa Canal. I recall he submitted his plan to the government and the municipalities and there were critics who said that Chippewa power would never be absorbed. The Chippewa project cost from $70,000,000 to $80,000,000 and it served the people."

Recalling the prophecies of the skeptics of Sir Adam Beck's day, the speaker told of a friend who had been warned by "an eminent American engineer" that there would not be sufficient water in the Chippewa Canal to turn the first unit of Chippewa.

"But we pinned our faith in the Hydro engineers and the Hydro commission. And there was no great surprise, even to Premier Drury, because he was skeptical, too, but the late Sir Adam was not skeptical. He never had a doubt. Those associated with him, particularly Engineer Gaby, knew he wanted every detail, and that when he said 'Go ahead,' there was no turning back. And so the Chippewa development of 60,000 horsepower, per unit, was turned on."

Other possible sources of supply were the Niagara River, the St. Lawrence River and the Ottawa, the speaker pointed out. Sir Adam Beck and the present chairman considered the field, he recalled, as they had been alarmed by a possible power shortage. A complete survey to carry the commission until 1937 was ordered and undertaken.

The speaker told of negotiations with United States for further development of Niagara Falls. An agreement between the governments of Canada and United States was suggested, but for some reason United States did not go through with it.

"Therefore," he said, "the commission looked toward the possibilities of the St. Lawrence.

"Negotiations between the Dominion and United States Governments were finally undertaken," the speaker said, "but the final endorsement of the U.S. Senate is not anticipated before January. Meanwhile, notwithstanding a popular impression to the contrary," he said, "it would be 1943 before the St. Lawrence power would be available, even if work were to be started next year.

"It was imperative that the commission should look about and see

that there is no power shortage," explained the speaker. "What is going to happen between 1937 and 1943?

"The Gatineau power contract has been practically absorbed. What are we going to do? You business men must bear in mind that if an industrial expansion takes place in this province, what will you do, if we have to shut off power at certain hours of the day because of a shortage? For myself, I do not want any responsibility for a power shortage."

Without mentioning any of the commission's more recent deals, the speaker asked if any person would question the wisdom of a plan whereby private companies built their own developments and the commission purchased the power from them.

The speaker lauded the "wisdom, foresight and energy of the Hydro executives" and the "ever guiding hand of the chairman" in its enterprises calculated to circumvent a possible shortage of power.

For the critics of the commission, he said: "They do not know anything about Hydro. They are doing this province a great harm. Would you question the management of a concern if it were returning dividends as this commission has done through the years of the depression?

"Every debenture when it becomes due will be paid. The position is unassailable. And close on to 80 municipalities have paid off their entire indebtedness and have government bonds and securities in their treasuries. These are facts which canot be questioned except by men who do not know what they are talking about.

"I appeal to you to stand guard as shareholders of this organization, regardless of party politics, and not let these people malign it."

The speaker recalled that this week a member of the Quebec Legislature, a Liberal, had cited Ontario's Hydro policy as a model to be followed.

And Hydro, he added, is going to "place Northern Ontario in one of the most enviable positions of any country in any part of the world."

Dealing with the Walkerville situation, the speaker said that the number of consumers in that town had jumped from 1,412 in 1914, the year of Hydro's inception there, to 2,885 at the end of 1932. The revenue in those years had increased from $64,000 to $290,000.

"What does that mean?" he asked. "What have the efforts of Mr. Woollatt, Mr. Green and their associates meant to you? It meant you have been able to hand over to the people of Walkerville $10,709,924.67 based on the rates of 8 and 10 cents per kilowatt-hour, charged by the private interests.

"And not one five-cent piece—and this statement has often been questioned—never have the people been asked to contribute one cent in their tax bills to Hydro for its service. It seems strange, but it is so.

"Since 1918, your 13th bill has shown a continuous credit in Walkerville. And those surpluses run into a total reserve of $935,859.30. And your average cost to lighting consumers has decreased to 1.62 cents per kilowatt hour as compared with 5.23 cents in 1914.

"And now for my good friend, Mayor Croll, of Windsor. He will be

glad to hear this report. In 1914 Windsor Hydro plant capital was $389,000. In 1932 it was $3,564,000. In 1915 its reserves were $9,899.06 and to-day its reserves total $2,739,-375.97. They have handed back to the people, based on the 1914 rates, an amount of $40,765,825.51. It sounds like a fairy tale, but it is a fact."

The speaker submitted statistics which revealed that Windsor's net operating surplus had jumped from $5,324.87 in 1915 to $619,230 last year. And to-day the total reserve is $2,739,375.97.

"And if Bill's vision had not prevailed, that $40,000,000 savings, three times that amount, would have gone into the coffers of the private interests," the speaker contended.

Commissioner Maguire concluded with a prediction, based on Hydro surveys, that "we have turned the corner and are now on the main street of prosperity".

Reasons Why Hydro has Attained Success *and* General Conditions in Canada

By Right Honourable Arthur Meighen, P.C., K.C., Commissioner

Address at Testimonial Banquet by Walkerville Hydro-Electric System to Commissioner W. R. Woollatt, from a verbatim report by the Border Cities Star.

MY very frequent presence in the Border Cities will surely add some touch of sincerity to an assurance that it does not take any very great excuse to bring me back in your midst. My memories go over several years to battles won and battles lost in this interesting sector of Ontario, but still more fondly to friendships on all sides which emerged both from victories and defeats.

But if it takes little reason to bring me, that does not mean that abundant reason did not exist on the present occasion.

I do not know anything that a community usually fails in more than recognition of the quiet, unobtrusive citizen who does his duty. Your honoured guest to-night has been a very close, a valued political friend and ally of myself, as well as having served this district admirably in important posts, and my tribute to him to-night must take its origin wholly from the latter virtue and not from the former.

It is altogether too much a habit in democracies to exalt certain men away above their merits, to imagine that they have some super qualities and because they hold or have held positions high in the state, to value their services above the services of others back in the ranks or in subordinate posts—who really do the work,

achieve the results and ought to have the credit.

One is sometimes given more criticism than he thinks he should have; his character is besmirched and all the rest of it; but also he is given far more in plaudits in relation to his fellow citizens than he is entitled to. Therefore, it is good on occasion to give recognition to the rank and file. In all parts of our country, we find the quiet citizen who does his work. There is everywhere some village Hampden or some undiscovered Cromwell who passes his life and never is given the public reward which fairness and candour make his by right of service.

You have one in your midst, and you have been good enough to say so, and I know this night will be treasured by Mr. Woollatt and he will pass the imprint of it on to his family as one of his finest possessions and richest memories.

I am very anxious not to impose long on you to-night, not that I am not willing, but I have spoken so distressingly often in Windsor on matters of Hydro that it becomes wearisome repetition, and I think an imposition.

I am going to try to put something simply to you—and nothing is worth saying if it is not simply expressed—of the main reasons, and I think there are only two, why Hydro has attained the success it has in this province.

Some of you may be apprehensive that I am going to belaud the virtues of the commission or of past commissions, and that I am going to say Hydro has been better administered by them than other enterprises. I think it has been well administered and has been fortunate in its personnel. But I am not going to attribute to that fact the main volume of success which has followed in the train of this undertaking.

The first reason for such great success I think is this. It was initiated in the early dawn of electrical development. It meant the acquisition and distribution by the state of Hydro powers in our province. It prevented by such policy multiplication of individual companies, duplication of plants and distribution systems, triplication, quadruplication, the multiplication of them, and consequently relieved the taxpayers of our province of the necessity of paying interest on huge capital structures such as has been a burden to other states and other provinces on this continent.

You have one system, no duplication, nothing in the nature of multiplication. You are paying interest and carrying charges only on what you must have in order to get the services which electricity will give.

In a word, it is because of this attainment of unification of the whole under a single commission—at the same time preserving the fullest local control of local services—that a common policy, and a maximum economy result.

To this fact can be traced a great proportion of the benefits which Hydro has brought to the people of this province. If we had not this plan we never could have produced the figures which have been given by the other speakers, we never could have reduced the cost of electricity as they have revealed, we never could have diminished the debt with ultimate ownership by vast sections of

Ontario of the great investment in Hydro they now possess.

But there is another factor. There were two methods by which the generation of electric current and all its services could have been brought about as a state institution in Ontario. The obvious, and probably the one that first struck the minds of the founders of Hydro, was to have the Province of Ontario take hold of the undertaking, have the province supply the money and superintend the work.

Possibly they could have had the Province of Ontario appoint what might be called an independent commission, and have the whole thing operated by that commission aside from the government. In such a way our National Railways are run.

The directors who supervise and manage that system are appointed by the Government of Canada. Then, if this had been done with Hydro, we would have had one system all right, but I fear we would have had many of the defects, many of the difficulties, and many of the just criticisms that have followed in the wake of our National Railways in Canada.

Another scheme was adopted, and I hope when I get through every one here will understand it.

It was a scheme of partnership of municipalities, leaving every municipality free to come in or stay out of the undertaking; in a word, the basis of the whole thing was the municipality, and not the government at all. I believe some 13 municipalities formed the first partnership, then others were invited, and to-day the partnership embraces some 757 in Ontario.

Now, understand the municipalities are the stockholders of the whole enterprise and all that belongs to it. There are no other stockholders, no other individuals, no other partners. The municipalities own all the property, and they own it not in proportion to wealth, but in proportion to the service that the municipality takes and pays for from the partnership.

They own it in proportion to the reserve the municipality builds up under its own operation. But the main thing is that they own it, and they own it all. There is not an asset that is not the property of the separate municipalities, each holding its own equity.

Some who came in early and have had special advantages have been able to conduct their affairs so that they own their local properties entirely. They either have paid off the bonds and mortgages entirely, or have liquid assets already to pay them off at maturity.

Others are nearly in this position, and each is operated on its own merits, each in relation to the system in its own boundaries and in relation to the over-riding system operated by the Ontario Hydro Commission.

Now some of you may say: "How can we be the owners if we did not supply the money to buy and to operate?"

You did supply the money to operate—the money is supplied by your own consumers. The money to buy was supplied by the province, which assumed the position of banker to the enterprise, and the position of banker is what it occupies now—and no other position at all.

With the National Railways, the Dominion Government is the owner of the system. The Dominion Government being the owner is necessarily charged with a direct responsibility for operation, from which it has never been able to divorce itself, and consequently the National Railways are vastly more in the orbit of politics than has been the Hydro.

It is because through the interest of citizens in their local Hydro affairs, and through the local election of Hydro officials, we have been able to get the co-operation of the people and the municipalities and to keep contact with them.

In this way the operation of Hydro is far removed from the ordinary field of politics. And in this we have the chief ark and covenant of Hydro, and I want the people of Windsor to understand that the man who seeks to have Hydro in any other atmosphere than that created by its founders, whatever may be his pretense, is no friend of Hydro at all.

By way of tribute to those who are chiefly responsible for this, let me say the principle of this foundation in and around the municipalities aside from the government was nothing short of a stroke of genius. I do not know any precedent for it in the world. I do not know anywhere else in this or any other continent where you have public ownership on that basis.

Public ownership has its merits and its defects, but nowhere else has public ownership succeeded as it has in the Province of Ontario. And I for one attribute the success of Hydro to that principle of organization which we must in honesty attribute to the genius of Sir Adam Beck.

I said the government was the banker of Hydro. This has been shown by the chairman of the commission to-night in the clearest and most impressive way. The government has advanced the money on the credit of this organization. It is the banker furnishing the money, and, owing it to its people that this money is repaid, it takes the precaution of naming the members of the central commission, who are mainly responsible for the conduct of the undertaking.

It names them because the function of management must be to see that the financial lines are such there is no danger of Hydro running on the rocks.

That is why the commission should be so named, no matter what the complexion of the government.

The others, that is local boards, are named by the people themselves, save in the larger centres of 60,000 or more population, where the investment of the government as a lender is so great that the voice of the central commission should be more direct on the boards of these larger places than it need be in the operation of the smaller.

The government being the banker, we being appointed by that government as trustees of the municipalities —not trustees of the government at all, we own nothing, we hold all for the municipalities—we are appointed by the government to see that the money is paid; our first duty is to make that certain. And let it be known, the Hydro Commission has made it definitely certain that the Province of Ontario stands

in the enviable position it does as defined by the chairman.

Don't think it is to make the management political that the government appoints the board. No matter what government is in power, it will be its bounden duty to appoint the board—at least until the time when the entire debt of Hydro is extinguished. It is inconceivable that time will ever arrive, because there are always new developments and new needs, and we will always be in the position of borrowers, at least as long as Hydro is progressive.

* * * *

I was told before I rose that I would be expected to say something of general conditions.

I know that here in this western section of our province, where growth and expansion was perhaps the most rapid of any in Ontario, the hand of the depression has borne heavily upon you. For the reason chiefly that you were the beneficiaries of a rapid growth, you have had to bear more than your share of the difficulties which that growth entailed when the turn of fortune came.

Therefore, you are doubly interested in efforts to steer our country out of the shallows in which we landed some three or four years ago.

What I intend to do is to state in the simplest possible words, the chief factors of the position in which we are and then to make some brief enquiry as to whether the difficulties which these factors brought upon us are being removed or not.

Some of us thought, years ago, that the cycles of depression and of advance had probably disappeared or at least partially evened out. We are all now disillusioned on that score. We do not know whether banking principles can be so altered as to modify them in the future or not. But we do know that just at the time we thought we were in the most secure position, we ran into the deepest, longest and blackest depression this country has endured.

There are some features fairly clearly defined. First, we know that we have war debts. I do not know that they are the principal trouble by any means, but that they are a great and a major factor there can be no question.

War debts generated by the conflict of some fifteen or twenty years ago are debts between the nations. They can only be paid by services or goods, not by money as can debts be paid between people inside a nation. You cannot convert the coinage of one into the coinage of the other for the payment of debt. If you do, all you really do is increase the debt.

They can be paid only by goods or services, and the policies, particularly of the creditor countries, became such that goods could not be delivered, services could not be rendered; they forbade the goods to enter, they forbade the services be given.

And so a dark miasma gathered over the affairs of the world, benumbing trade and disturbing confidence. That was a major cause in bringing about this depression.

There were others. Without a doubt the unprecedented advance of machine production has put the whole economic machine out of balance. Machine production is nothing new; it has been with us for a hundred years; but the pace to which it has been accelerated has developed par-

ticularly within the last fifteen years. The rate at which tens of millions of workers have been displaced by machinery has been prodigious and alarming.

For the first part of this period, while it displaced thousands, it also created work. New discoveries were made, new wants found, new services were developed. These absorbed the energies of men displaced. But economists have shown that this power to absorb was overtaken about the year 1919. From that time on, displacement has multiplied, power to absorb has been reduced, and consequently we had and have still a tremendous unemployment, in volume utterly unparalleled in the history of the world.

To-day if we could return to the maximum production of 1929, we never could begin to take on the men displaced since 1923. We would have to have a production far exceeding that of 1929 to do anything like reduce unemployment even to the enormous proportions of the last decade.

When you displace tens of millions of people you contract consuming power, and therefore buying power goes down, production power goes up, and the whole mechanism is out of balance. We are paying the penalty of our own progress and inventive genius.

We find now that these advancements bring in their train penalties. We have in some way to pay for the progress of mankind.

The United States addresses itself to this problem and endeavours under government supervision to distribute the leisure which is as much the product of the machine as goods. They hope by their National Recovery Act to divide the work. They are best situated and qualified to try this experiment. Its success lies in the lap of the gods, but every nation will look on with sympathy and hope that the method that country has tried will meet with some measure of success.

Then there is another factor. We are talking to-day about the National Recovery Act being an inflation plan. We are talking about Mr. Roosevelt's gold buying plan being an inflation plan. I do not doubt in some senses it is. But we are talking as if we had never seen inflation.

What is inflation? It is an unnecessary, unnatural, improper expansion of credit or of money. We have three kinds of money. First there is metal money. That is limited in quantity; in all the world there is only eleven billions in gold. Next is currency, issued by governments and banks; from two and a half to three times the amount of gold with which that currency is secured. These are two forms of money.

But in the evolution of civilization another has developed, vastly more important, vastly more elastic, vastly more perilous. That is the form of money which is called credit, bank credit, which exists the world over.

Bank credit is not two and half or three times currency; it sometimes runs to ten times; and in the fearful inflation period up to 1928 in the United States of America it ran to fifteen times. Indeed, at a time when the banks of the U.S.A. showed deposits running to about seventy billions, they actually did not have currency or metal to answer these deposits

to the amount of more than five per cent. Twenty times the actual money were the deposits standing to the credit of citizens of that country in their banks.

In Great Britain something similar took place, but no to such an extent. There are there five great banks only, and currency is in the hands of the Bank of England and they do not permit the volume of bank deposits to exceed currency by more than ten times. That is vastly different from twenty, and because they have only five banks and central control, they are able to curtail credits and avoid such terrible excesses as occurred in the United States.

In Canada we have nine banks. We are a minor factor in world affairs—not insignificant, but minor; but we are in a vastly better condition to control credits than is a country where there are thousands of banks, because in a country where the banks run at large, it seems impossible to exercise that rigid supervision of credit which Britain was able to impose.

In consequence the force of the depression was felt with more severity in the United States than elsewhere. The United States had had a great advantage from the war—three years of selling supplies to warring nations. The United States became the world's great creditor—and yet because of their great credit expansion, it felt the force of the depression more violently than other lands.

One lesson is:—we must first find some way of dividing the world's work. We must find some way of distributing the world's leisure, because if we cannot do that we cannot divide the world's work; and we must find some way—I do not refer to Canada alone because we are a minor factor—we must find some way of controlling the dangerous expansion of bank credit.

It is due to the far greater soundness of Britain's financial institutions that they to-day are well up the hill, while the position of the United States is at least doubtful.

Many who looked with pity—real or assumed—on the distress of old England with her unemployment, and her globe circling obligations are now pretty well chastened by the experience of these last four years; and the leadership of world finance, which had a short and tragic sojourn on this side of the Atlantic now has returned and is vested in the people of England again.

We in Canada have some reason to take pride that we enjoy the immediate leadership of that great people, that people who have known success and difficulty, who have faced for centuries perils unnumbered and privations but who to-day enjoy a prestige because of their recovery which places them again in the forefront of the industrial nations of the world.

I do not propose to detain these people any longer, except to bring home an outline of our own position.

Are we going to be able to avert this credit danger better with a central bank than without? I do not feel myself qualified to give an answer. I do not look to a central bank to exercise any tremendous revolution or bring about any sudden emergence from trouble in Canada.

Whether it will do any great good is not agreed. But it should give Canada a chance to control credit better than if we do not have it.

We are emerging from the depression because of natural forces. The world is emerging. This is clearest of all in Britain. It is fairly clear in Canada. It is most obscure in the United States. But speaking in terms of the world, there does not seem much doubt now that the road back is being slowly traversed.

We are at least a year and a quarter from the lowest depths, and I do believe that the journey up, while it is slow and while it is arduous, is just as hard to be reversed as was the journey down.

It proved impossible by all devices to impede a precipitous descent down the hill until we went to the very depths. I do not think even a blunder on the part of any one country —and I do not assume any country has blundered—will wholly stop the upward ascent.

The general movement has been on the whole upward over an appreciable period of time.

You people in this district who have an undue burden to bear, an undue but inevitable price to pay, should not be disheartened. Let every one do his part, every man in the ranks every officer at his post, for never was clearer, the soundness of the maxim, and it ought to be kept ringing in these Border Cities, that "the darkest hour is just before the dawn."

O.M.E.A. and A.M.E.U. CONVENTION

at King Edward Hotel, Toronto

January 31 and February 1, 1934

Ontario Farm Products Cooking Schools and Demonstrations of Electric Ranges, Refrigerators and Kitchen Equipment

At the request of the Minister of Agriculture, the Commission arranged to co-operate with his department by setting up for demonstration electric ranges, refrigerators and kitchen equipment loaned by manufacturers, for two-day cooking schools to be held in twelve trial locations extending from Aylmer in the west to Napanee in the east, to bring together the consumer and the producer to emphasize the importance and value of Ontario farm products to meet the diatetic needs of the consumer.

As cities are having cooking school demonstrations by manufacturers, the itinerary was planned to carry these demonstration schools to towns, villages and rural districts only. Schools were held in Aylmer, Strathroy, St. Marys, Exeter, Brampton, Milton, Orangeville, Newmarket, Lindsay, Port Hope, Brighton and Napanee.

The classes had an average attendance of 230, a maximum of 340. In two of the twelve locations, the bad weather interfered with attendance, thus affecting the average.

Set-up for the school and demonstration held at Napanee.

The tented city f

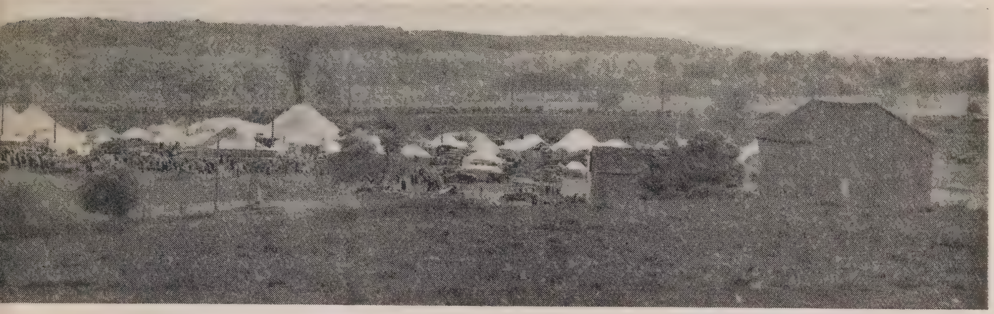
Hydro Demonstration at Provincial Plowing Match

THIS year the Commission again gave a demonstration of equipment for the application of hydro-electric power for the farm home, barn and dairy, at the Provincial Plowing Match held at Owen Sound on the farm of Mr. Vernon Barber, four miles south of the city.

The equipment was housed in a tent 40 ft. by 60 ft., divided into two sections, one for household equipment and appliances and the other for equipment for use in the barn or dairy on the farm. In the household section was a variety of ranges, washing machines, a refrigerator, ironing machines and appliances as well as blowers for coal burners. In the barn and dairy section, no line shafting was set up this year, as farm equipment has so far developed that very little line shafting is now needed. The utility grinder motors may be belted with a very short piece of line shafting, if any, and the other equipment is arranged for direct-motor drive. This year, for the first time, underearth heating was on display as well as a low power feed mixer and milk cooling equipment.

The tent city comprised about 70

The Hydro and adjacent tents with the crowd.



djacent height.

Milk cooler, utility motor feed grinders, undersoil heater and the feed mixer.

concessions and made quite an array when viewed from the high land adjacent to it. In order to supply electric service required by the Hydro tent and 27 concessionaires, an extension of primary line was made of 300 feet at the end of which was erected a 15-kilowatt transformer and 1,000 feet of secondary line.

The water system consisted of a deep-well pump which had its supply from a drilled well, driven by a 1.5-horsepower motor, the unit having a capacity of 1,000 gallons per hour. A piping system built by the Owen Sound Waterworks Department, consisted of 700 feet of 1.5-inch pipe and 300 feet of extensions from

Electric pumping equipment and the utility motor feed grinder.

Milking machine, cream separators and electric motors.

Electric ranges, washing machines, etc., in the household section.

The transformer set-up, the secondary main and part of the crowd on the front street.

a distribution centre. Six taps were used and the capacity was such that if one or all taps were turned on each had a sufficient supply.

In the background of one of the pictures may be seen a mile of cars on the highway. In the foreground are cars in the parking area for concessionaires. These were only two of several parking areas.

It is estimated the attendance on one day was approximately 35,000 and the total attendance for the four days 70,000. In view of the fact that this is the first demonstration in the northern part of Old Ontario, it was very well patronized, and although on some days the weather was inclement at the beginning, it did not seem to dampen the ardour of those wishing to attend.

Attacks on the Atom

On the evening of October 10, Lord Rutherford, F.R.S., broadcast an address on the National wavelength on "The Transmutation of the Atom," in the course of which he surveyed various aspects of the investigations upon which he has been engaged for the past thirty years, and gave an account of methods which have been devised for conducting the attack on the atom. There seemed to be little prospect that we could hope to obtain a new source of power by these processes. It had sometimes been suggested, from analogy with ordinary explosives, that the transmutation of one atom might cause the transmutation of a neighbouring nucleus, so that the explosion would spread throughout all the material. The absence of accidents indicated, as would be expected, that the explosion was confined to the individual nucleus and did not spread to the neighbouring nuclei. Taking the radius of the nucleus as the unit, other nuclei were relatively far removed from the centre of the explosion.

The general law of conservation of energy appeared to hold in these intense nuclear explosions. On modern views, energy and mass were closely related and any decrease of mass of a system involved the necessary appearance of a definite quantity of energy in one of its characteristic forms. In the lithium transformation, the relative masses of the proton, nucleus, and alpha-particle were known with considerable accuracy. When account was taken of the change of mass of the system before and after the nuclear explosion, and the kinetic energy of the expelled alpha-particles, it was found that there was a close balance, showing that this generalized form of conservation of energy held within the accuracy of the observations. It was to be hoped that this law of conservation would prove a reliable guide in interpreting other types of nuclear reactions.

The results of these investigations were not only of fundamental importance to science in giving us new knowledge of the structure of nuclei, but had a considerable bearing on problems of cosmic physics. In the furnace of the sun and other hot stars, the electrons, protons, neutrons and atoms present must be endowed with high average velocities owing to thermal agitation. It was thus to be

expected that the processes both of disintegration and aggregation of nuclei, such as were observed in the laboratory, should be operative on a vast scale for all nuclei, and that a kind of equilibrium should be set up between these two opposing agencies of dissociation and association for each type of atomic nucleus. The information to be gained on the efficiency of various types of agencies in transforming atoms might help to throw light on the reason for the relative abundance of different elements in our earth, and thus in the sun.

POWERFULL NEW DEVICES

As to the prospects of obtaining further knowledge of transmutation in the near future, the main lines of attack were sufficiently clear to allow us to look at any rate a short distance ahead. Plans were being matured in many laboratories to obtain much higher voltages and faster particles of all kinds for a further intensive attack on the problem. Van de Graaff had devised a new type of electrostatic generator whereby he hoped soon to obtain a steady potential of 10,000,000 volts with which to accelerate atoms in a discharge tube. This voltage would give a miniature lightning flash more than 50 feet long. Lawrence, by a special method of multiple acceleration, hoped to obtain projectiles with energies greater even than those carried by alpha-particles from radium.

Observations were also being made on the transformation effects of the extremely energetic particles present in the cosmic rays which passed through our atmosphere. Many of these had an energy of 100,000,000 volts while some were believed to have an energy of more than 1,000,000,000 volts. No doubt, also, the possibilities of transmutation by high-frequency radiation of the gamma-ray type would be carefully examined.

There seemed to be little doubt that by the use of still faster particles of different kinds, and possibly by other agencies, we might hope in the next few years to observe the transmutation of some of the heavier elements on a small scale. A successful method of attack on the general problem had now been opened up, and very powerful yet delicate devices were available for studying the effects which might arise. No one could be certain what strange particles or unexpected phenomena might appear.

—*The Electrician.*

Lighting Chats Falls Development

By C. B. Stephens, Electrical Engineering Department, H.E.P.C of Ont.

IN designing a lighting layout for a large generating station, there are three cardinal requirements to keep in mind. First, it is necessary to provide adequate illumination to meet all operating conditions. Secondly, lighting equipment must, as far as possible, be installed according to current practice, and conform with various economic principles. Lastly, all lighting equipment and services must be easily accessible for maintenance purposes. With these principles in mind, an adequate, yet economic layout was prepared for the Chats Falls development.

This large plant comprises the generating station housing eight 23,500 kv-a. generators, the four 47,100 kv-a. outdoor transformer banks and the high voltage (220 kv.) switch yard.

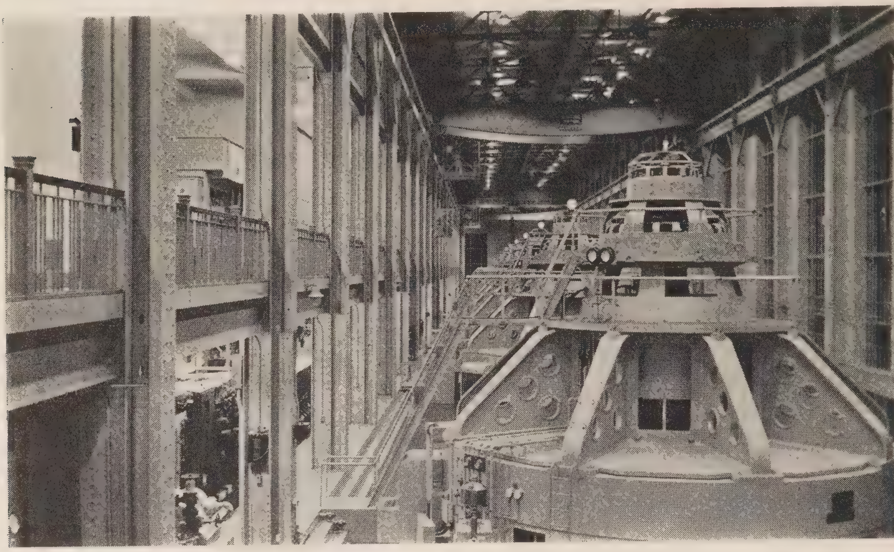
In designing the power supply for station auxiliaries, energy at 575 volts was eminently suitable except for small motors and circuit-breaker heating in which case 220 volt ratings are necessary. This voltage would be obtainable by making the lighting supply 3-phase, 4-wire, 120/208 volts. Considerations affecting layout such as size of feeders, transformer locations and branch wiring to the light outlets indicated the economic superiority of the 3-phase, 4-wire system over the single-phase or 3-phase, 3-wire alternatives.

Final design based on ultimate lighting, heating and motor loads at lighting voltage resulted in two transformer banks in the generating station, each comprising three 50 kv-a., o.i.s.c. transformers with 600 volt primaries and 120–240 volt secondaries connected 120–208 volts star. A twelve-circuit distribution panel, fed from each transformer bank, supplies feeders to lighting panelboards, battery-charger sets, generator oil pump motors and a 400 ampere tie between the two distribution boards.

A 44-circuit lighting panel is built into the left-hand end panel of each generator switchboard comprising exciter controls, relays, etc. Each circuit is protected by an automatic thermal overload type circuit-breaker connected to the bus-bars in such a way that any three consecutive breakers in a vertical row will form a 3-phase, 4-wire circuit when combined with a solid neutral wire.

An important feature of design was to maintain simplicity and symmetry in layout to facilitate installation and care during operation. Besides the arrangement of branch circuit connections already described, branch circuit wire was supplied in four colours—red, blue, green for phase wires and grey for neutral, the colour being in the wax finish. All branch circuit-breakers on the eight panelboards were rated at 20 amperes.

Most of the branch wiring was No. 12 B & S except that running appreciable distances from the panels.



Night view of generator room floor, Chats Falls development.

GENERATOR ROOM LIGHTING

In the generator room outlets were rated for 1,500 watt lamps maximum, spaced 21 ft. 8 in. by 25 ft. and mounted approximately 50 ft. above the floor but readily accessible from the travelling cranes. Prismatic high bay reflectors having spun aluminum covers were used with 1,000 watt lamps.

GALLERY AND CONTROL ROOM LIGHTING

On the upstream side of the generator room are three galleries, the lower one accommodating governors and governor pumps, station service switching, generator panels, etc.; the middle one housing main 13 kv. switching and station service transformer banks, and the upper one the control room, offices, stores and headgate machinery. Lighting units on these three galleries vary from 200 to 300 watts in size and all are supplied with prismatic industrial type reflectors and utilize inside frosted lamps. Indirect lighting is used, however, in the control room and offices. Spacings are roughly at 10 ft. centres and mounting heights 12 to 15 ft. The open bottom reflectors make relamping a simple matter while the inside frosted lamps, combined with the cut-off angle of the reflectors, eliminates objectionable glare.

Emergency lighting outlets are located at all gallery stairways, station service and generator switchboards and in control room. These outlets are normally energized from a.c. power but on failure an automatic transfer switch throws over to the station control battery. There is also a 300-watt street lighting type refractor unit mounted on the edge of the second gallery floor opposite each generator which is energized on failure of the a.c. power. Current to these lamps is normally kept off by

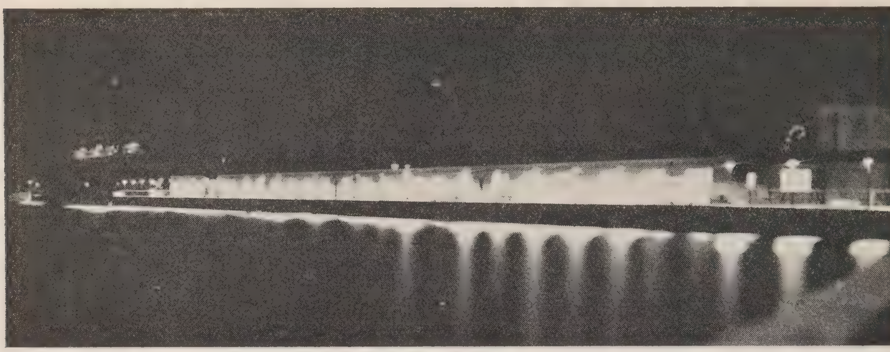
Transformer station at night, Chats Falls Development.

120 volt d.c. contactors being interposed between the emergency lighting panel and these particular circuits.

Lighting for the tunnel beneath the transformers and adjacent outdoor lighting is supplied by a feeder from the nearest distribution panel. Outdoor sub-station lighting units serve to illuminate the 220 kv. transformer disconnects while smaller outdoor prismatic units illuminate the oil gauges on the transformer conservator tanks and the walkway below. A circuit-breaker type panelboard located in the transformer tunnel protects the branch circuits.

The high voltage switch yard required lighting of the various disconnecting switches, interior lighting of the small relay house, and also 16.4 k.w. of heater load for each of the nine circuit-breakers. Here again, the 3-phase, 4-wire arrangement is well suited for both power and light. In the relay house is a circuit-breaker type panelboard divided into two similar parts. An upper section of each part of this board comprises eighteen 50 ampere, single-pole circuits for oil circuit-breaker heating and a lower section of eighteen 25 ampere circuits for lighting. Branch

Switching yard at Chats Falls development showing night illumination.



Chats Falls powerhouse in a blaze of light, even on the darkest night. This photograph, taken from the dam, shows that adequate light is provided for all operating emergencies

circuits are connected such that any three adjacent switches form a 3-phase circuit. Each part of this panelboard is fed by three 50 kv-a., 600/120-240 volt transformers located adjacent to the relay house and connected for 120-208 volts star on the secondary.

OUTDOOR LIGHTING

The outdoor substation lighting units for the switch yard are mounted on pipe standards 10 ft. high and placed either side of a disconnect switch stand on its transverse axis. A lighting unit between two stands on the same transverse axis is placed to light both stands to the best advantage.

Suitable lighting was required at the headworks and at five sluiceways for night handling of stop logs, and for safety in walking along the intervening stretches of bulkhead wall. This lighting extends for a distance of about 3,500 ft. from the power-house towards the Ontario side of the Ottawa River and towards the Quebec side.

Each lighting unit is mounted on pipe attached to a cast iron railing post and embodies a porcelain enamelled shallow dome reflector and a 200 watt inside frosted lamp. The reflector is mounted 10 ft. above the deck so that lamps are replaceable without appliances. On the headworks and sluiceways where work is done at night, spacing of units is 48 ft. and on intervening bulkhead wall it is 72 ft. There are over 150 of the lighting units in all.

Power to serve this lighting is obtained from circuits carried on a steel messenger cable supported on the downstream face of the wall. A 3-phase, 600 volt primary cable supplies three 5 kv-a. transformers spaced along the 3,500 ft. of bulkhead wall where it is stepped down to 120-240 volt secondaries carried on the same messenger and tapped to each light outlet through a 1-in. pipe extending from the messenger location to the bottom of the railing post supporting a light.

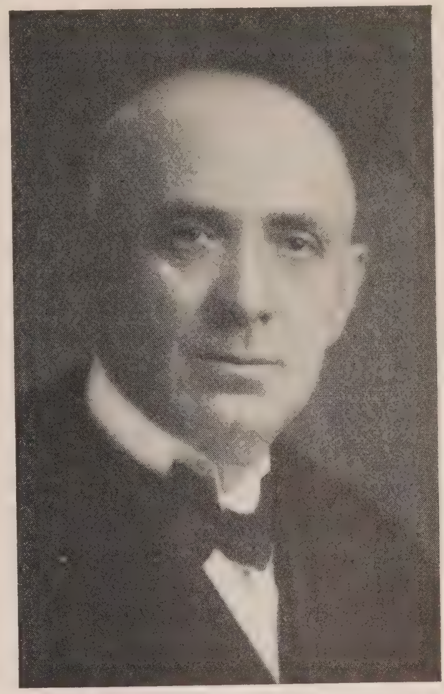
In addition to the fixed lighting equipment, there are four 500-watt floodlights located on each of the two generator room cranes and on the headworks gantry crane. Four stop

log winches on the sluice gates are equipped with 200-watt local lights. All these lights are supplied through step-down transformers located on the machine from the power circuits. It has been found that such local lighting suitably arranged is a valuable aid to the operation of the equipment.

It will be observed, therefore, that the dominating idea back of the actual design was to make each detail of the lighting equipment and wiring simple, harmonious and best suited to the purpose intended at reasonable cost.

—*Electrical News and Engineering.*

George W. P. Every, Whitby



George Washington Post Every

One of the most faithful and efficient public servants and outstanding citizens of the Town of Whitby, passed away at his home on the evening of Sunday, October 29th, 1933, in the person of Major George Washington Post Every. Mr. Every had not been well for a week but his condition had not caused any alarm, but at seven o'clock Sunday evening he was seized with a sudden heart attack.

For twenty-two years Mr. Every has served as Superintendent of the Public Utilities Commission of the Town of Whitby. In this capacity he had the management of the electric, water and sewage systems, and it was during his tenure of office that extensive additions and improvements were made to these. His work in Whitby can be said to have been a hobby, and he was noted for his exactness and thoroughness of detail.

Mr. Every was a member of a number of fraternal societies in all of which he advanced to high offices. He was interested in the work of the Whitby Chamber of Commerce and a member of the Executive Committee. He took an active interest in all public affairs and was always ready to lend a hand in the furtherance of any move for the public good. He was largely instrumental in raising a Whitby Company of the 116th battalion, which he accompanied to France and commanded with the rank of Major. Since his return from overseas he has taken a keen interest in the welfare of returned men, being a member of the Whitby branch of the Canadian Legion.

Mr. Every was born at Pickering, near Whitby, fifty-three years ago and has been a resident of the district all his life. He is survived by his widow and one son.

Electric Water-heating Characteristics

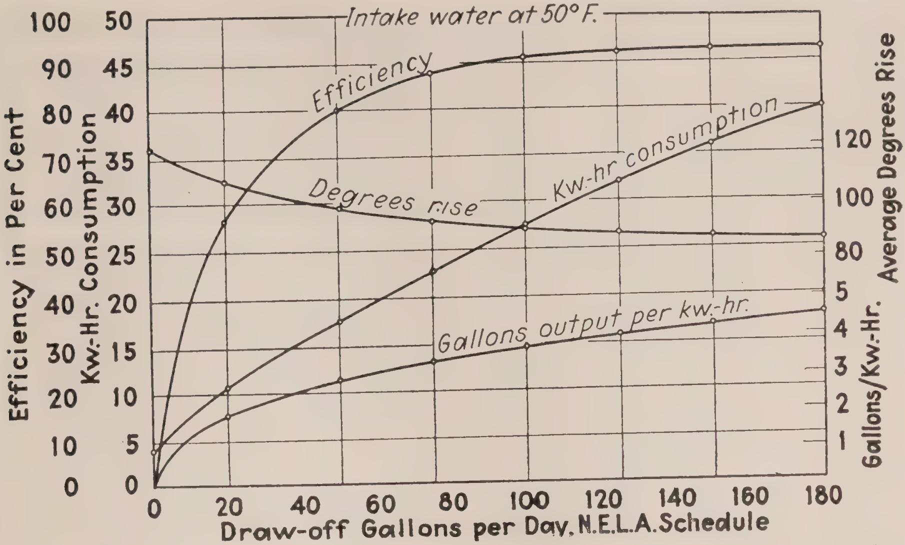
A RECENT issue of the Electrical World contains an article by George M. Palo, Puget Sound Power and Light Company, in which operation tests of electric water-heaters are described. These tests were made prior to the inauguration of a plan for the installation of electric water-heaters on special rates, to determine the design which would be most satisfactory both from the service and operating standpoints for this company. The findings, in general, are in accord with those from studies of the electric water-heater question by the Hydro-Electric Power Commission of Ontario. Portions of the report that are more particularly applicable to water-heaters installed on the Commission's free installation plan are extracted in the following.

The investigation was carried out using the data on hot water consumption as compiled by the National Electric Light Association. As reported, the average consumption of hot water in the United States is 10 gallons and the maximum 16 gallons per person per day. On the basis of the average family of 4.3 persons, maximum, normal and minimum days must provide for a hot water draw-off of 75, 50 and 20 gallons of hot water respectively. Under normal conditions there should be 13.4 normal, 5 maximum and 12 minimum days during each month.

Assuming the average conditions, the satisfactory water-heating installation must be capable of providing 75 gallons of water daily which will be above the minimum usable temperature of 120 degrees F. The problem is to determine the tank and heater size which will so operate without impressing undesirable demands on the system's facilities. In order to have good load factor and prevent a new peak from being added to the system it is necessary to use a small heater. However, if the tank is drained of hot water, the small unit will not give satisfactory service because of the time required to bring the water up to usable temperatures. Apparently the solution is the addition of a booster unit controlled by a separate thermostat, the small unit being used to take care of intermittent demands on the tank, with the larger unit assisting during periods of heavy withdrawals. With a 750-watt base unit heater and a 1,500-watt booster unit it was calculated that a standard 30-gallon tank would be capable of delivering the 75 gallons per day of hot water.

Tests were made on assemblies using clamp-on heaters, insert heaters and side-arm circulators and factory units of the insert, inside circulator, side-arm circulator and automatic control circulator types. Heating characteristics, maximum draw-offs and standby or idling losses were obtained from each of the above combinations to determine which had the most satisfactory over-all characteristics.

In making the tests water entering the tanks was measured by a standard water meter. To obtain accurate



Average performance in relation to the daily hot-water withdrawals. Both the efficiency and gallons output per kilowatt-hour increase rapidly up to the 120 gal. day, but as the draw-off increases the average water temperature decreases.

information on the heating characteristics of the various combinations of heaters a special tank having nine thermometer wells placed 6 inches apart down one side was used. Thermometers also measured incoming and outgoing water temperatures; the temperature of the hot water was taken at the start and the finish of each draw-off as it was being discharged into a wooden barrel for weighing and obtaining the mean temperature of the run. To obtain a record of the energy consumption of the base-unit heater and the booster heater a watt-hour meter and a recording ammeter were inserted in their respective circuits with a recording voltmeter providing a graphic picture of the voltage at all times.

Preliminary tests made it apparent that the location of the heaters, the points of application of the hot and cold water pipes and the location and setting of the thermostats were of vital importance to tank performance. Subsequent studies were made to determine the most effective types and arrangements of heaters and tanks. To make the thermostat settings uniform in all tests the booster thermostat was set to cut off at a water temperature of 150 degrees and the base unit when the top temperature reached 170 degrees, this being the maximum allowable temperature above which alkaline deposits begin to collect inside of the tanks and pipes and around the elements themselves.

Clamp-on Heaters—Two combinations of clamp-on heaters were tested, the first with the 750-watt base heater 4 inches from the bottom of the tank and the 1,500-watt booster unit installed midway between the

top and bottom and the second with the base heater 12 inches from the bottom with the booster unit 20 inches from the top. Of the two, the second combination was superior both in efficiency and draw-off characteristics. With the booster heater located near the top of the tank the water in the top of the tank heats up much faster, which lowers the time of operation of the booster unit and increases the recuperation characteristics of the tank. With the first combination the tank would be capable of giving relatively large amounts of warm water, but very little hot water when subjected to the 75-gallon draw-off schedule. This combination also requires more energy as the booster unit operates a longer time.

Conclusions drawn from the clamp-on tests indicate that for a 30-gallon tank the booster unit should be located not lower than 20 inches from the top of the tank, as this combination barely came within the limits prescribed for the draw-off schedule. The minimum temperature of the draw-off water was 121 degrees F., only 1 degree above the permissible lower limit. Furthermore, with the booster unit high up on the tank, the load factor is better as the base unit operates longer and the booster unit cuts out more rapidly, which also reduces the demand of the water-heating installation. From the customer's standpoint the second combination is preferable, giving more hot water per unit of energy consumption than the other arrangement.

Insert Heaters—In testing insert heaters three combinations were used. In all of them the 750-watt base heater was placed 6 inches from the bottom of the tank, with the location of the 1,500-watt booster unit inserted 30, 15 and 6 inches respectively from the top of the tank.

As might be expected, in the combination with the booster unit far down on the tank the characteristics were similar to those of the clamp-on heater located at the mid-point. Recuperation was poor and temperatures were low under conditions of extended draw-offs. The total energy consumption for a 24-hour period was 21.96 kw-hr. of which the booster unit consumed 9.40. Under the 75-gallon draw-off schedule the minimum temperature recorded was 124.6 degrees F.

With the booster heater located at the other extreme, namely, 6 inches from the top of the tank, recuperation was almost instantaneous, and even if the tank was drained 3 gallons of hot water would be available almost immediately. Under continuous draw-offs the tank delivery would break down, and even under the test schedule the minimum temperature recorded was 118 degrees, 2 degrees under the permissible minimum. This condition, however, occurred only once during the test period, the other draw-offs being well above the low figure. The energy consumption on this combination was the lowest of the three, as might be expected from the rapid heating at the top of the tank, which acts to cut the booster unit out after a short period of operation. A total consumption of 19.91 kw-hr. was measured for the 24-hour period, the booster unit consuming 5.30 kw-hr. It is of interest to note that the base unit operated 19½ hours out of the 20 hours allowed

under the off-peak schedule. Under such conditions the demand is reduced to the minimum and the load factor is extremely good. This combination, with its relatively low consumption, is attractive to the consumer and, in cases where the hot water demands are not quite as large as the average, would be the best installation for both the consumer and the utility.

The combination with the booster unit 15 inches from the top of the tank struck the happy medium between the two preceding cases. In some respects it is superior to both and, as the following data show, probably is the most satisfactory for the average consumer. In the first place this combination combines rapid recuperation with the ability to withstand continued draw-off, successfully meeting the schedule of an 85-gallon day. On the 75-gallon day the minimum temperature recorded was 143.5 degrees on the 85-gallon day the minimum temperature was 129.5 degrees, this combination being the only one of the three successfully to carry the larger schedule. Secondly, the energy consumption is but a little more than that of the most efficient combination, the total consumption being 22.41 hw-hr. with the booster unit accounting for only 8.75 kw-hr. of this total. Thus, the load factor is good and the demand low from this combination.

From this series of tests, it is apparent that care should be exercised in locating the heaters in the tank if a satisfactory installation is to be obtained. With the booster heater located too near the top of the tank hot water capacity is sacrificed for efficient operation. With the booster placed too far down the tank both efficiency and water temperatures are sacrificed to the rather dubious end of obtaining large amounts of warm water. With insert heaters the entire tank builds up as a unit. For example, if a tank is full of 150-degree water and one-half of it is drawn off and replaced with 50-degree water the entire tank will drop to a temperature of approximately 115 degrees and build up from that point.

Side-Arm Circulators—In the preliminary tests made on assembled units using side-arm circulators several points of importance were discovered. In some of the units the hot water riser from the heater entered the tank 6 inches from the top, in others it went directly into the top of the tank, and in still another it went directly into the hot water draw-off pipe. In some the circulation through the riser was further restricted by leaving but a small opening in the pipe just above the heater. The restriction in the circulating column was for the purpose of obtaining hotter water and thus helping recuperation. While this did produce hotter water and thus, in a sense, did help recuperation, when storage is taken into consideration this feature is not desirable, as the top of the tank will get exceedingly warm and the bottom remain cold or lukewarm. This is not desirable, for we do not want a small amount of exceedingly hot water, but rather a larger amount of usable water. Similar trouble was experienced with those heaters in which the hot water riser entered the top of the tank or the hot water draw-off pipe. The

additional fittings required to bring the water into the tank served as restrictions, causing the water at the top of the tank to be very warm. Another point noted was that with the hot water riser entering the top of the tank or the hot water draw-off pipe considerable bypassing of cold water through the heater was taking place.

The best combination was that in which the bottom of the riser was connected 6 inches from the bottom of the tank and the top connected 6 inches from the top of the tank. This connection is recommended where suitable outlets are available on the tank, with the alternative of connecting the bottom of the circulator to the bottom of the tank, the riser entering 6 inches from the top as before.

Because there are a number of small, flat-rate, insert-type units now operating which could be converted to off-peak operation with the addition of a booster, a test was made using a side-arm booster unit. While the results are not as good as could be expected by the addition of a second insert or clamp-on unit, the installation is entirely practical.

40- and 52-gallon tanks—Because many installations will require a tank larger than 30 gallons, tests were made on 40-gallon tanks using 2,500 watts of heater capacity and 52-gallon tanks with 3,000 watts of capacity. Performance of the large tanks was similar to that of the smaller ones, it being possible to take a 130-gallon day from the 40-gallon tank and a 165-gallon day from the 52-gallon tank with a minimum temperature of 122 degrees. Factory units delivered 165 gallons with a 4 per cent. higher efficiency than the assembled units, one 50-gallon factory unit delivering 185 gallons of water a day, all at usable temperatures.

On the basis of the 30-, 42- and 52-gallon tank data, a curve was calculated showing the maximum draw-off that could be expected from still larger tank sizes. In computing this curve a maximum of 60 watts per gallon of capacity was used, with a maximum 5,000 watts for the 100-gallon tank. With this limit, the amount of hot water that can be obtained by increasing the tank size is limited by the ability of the heater to restore the tank to its original condition in the 24-hour period. Calculations indicate that the 150-gallon tank is the upper limit of tank size for a 5-kw. heater; beyond this less, not more, hot water can be expected if this sized heating unit is used continuously.

Plumbing Connections—Piping in a water heater installation is an important factor in good service. In equipping standard tanks with heaters, the type, location and connection must be considered. In instances where insert units are considered, with a tank not having the necessary holes at the right location, resorting to drilling and the use of spuds probably will cause a leaky connection due to the continuous heating and cooling of the metal around the heater unless welding is used in making the joint. Experience has shown that where drilling would be necessary, it is better to substitute another type of heater with the proper connections.

With side-arm units the best connection was shown to be that in which

the bottom of the circulator entered the tank 6 inches up from the bottom. This eliminates bypassing cold water entirely and leaves a layer of cold water in the bottom of the tank, which reduces radiation losses. Another precaution for good service is the use of a heat trap in the draw-off line, which eliminates heating all of the hot water pipes in the house and the associated radiation losses. The heat trap is a simple "U" in the line and may be made from four elbows and three nipples.

Thermostats—The location of thermostats is very important and dependent upon several factors. It is desirable to have the base unit come on after small withdrawals, and as the base of the tank is the only place where an appreciable temperature change occurs, it is necessary to locate the thermostat controlling the base unit at the bottom. Also to obtain a good load factor by dividing the work between the base and booster units, the booster thermostat must be set to operate at a lower level than the base thermostat. If the booster thermostat were located at the same level as the base control it would operate first, and all idling losses would be taken by the booster unit. Consequently, to avoid this, the booster thermostat should be located at or above the centre of the tank.

With clamp-on and side-arm installations the thermostats may be located in the same pockets as the units themselves. With insert units, due to inherent characteristics of this type of installation, the thermostats must be located above the units to prevent water in the top of the tank from becoming too hot before the energy is cut off. In this type of installation the preferred position for thermostats is directly above the units they control.

With this investigation an effort was made to limit the top water in a tank to 170 degrees. After some experimenting, it was found that with the side-arm circulator, setting the base thermostat for 160 degrees and the booster thermostat for 150 degrees, satisfactory temperature control of the upper half of the tank could be obtained with efficient idling performance.

To follow tank temperature closely, the thermostat should be strapped to and have metallic contact with the tank. A proper thickness of tank covering is necessary to eliminate the effect of outside temperatures and drafts. Proper facilities for accurately calibrating the thermostats also are necessary for satisfactory operation and good performance.

Tank Covers—In off-peak heating idling characteristics are extremely important. With a bare 30-gallon tank and a side-arm circulator, the losses were found to be 1,000 watt-hours per hour with a temperature difference of 100 degrees. To stay within the limit prescribed above, it was necessary to cut these losses to 175 watt-hours per hour, which meant providing a tank cover which was 83.5 per cent. efficient.

Test losses on various types of covers varied from 180 to 335 watt-hours per hour.

Association of Municipal Electrical Utilities

Nominations for 1934 Officers

The Scrutineers' report covering the nominations for officers of the Association of Municipal Electrical Utilities for the year 1934 shows the following names. These names are listed according to the number of nominating votes received by each. Those marked with a star (*) will appear on the election ballot if agreeable to the nominees. The elections will take place during the first day of the Association's winter convention which will be held at Toronto on January 31 and Februry 1, 1934.

President: W. R. Catton*, E. I. Sifton*, T. W. Brackinreid, E. V. Buchanan, R. S. Reynolds, D. B. McColl, H. F. Shearer and V. A. McKillop.

Vice-President: O. M. Perry*, R. S. Reynolds, G. E. Chase, W. R. Catton, D. B. McColl, R. J. Smith*, E. V. Buchanan, O. H. Scott, W. E. Reesor, A. B. Manson, J. E. Teckoe, J. E. B. Phelps, R. S. King, H. F. Shearer, Geo. Morley, A. L. Farquharson, J. E. Skidmore, J. R. McLinden, Chas. W. Wilson and F. N. Leavens.

Secretary: S. R. A. Clement*.

Treasurer: D. J. McAuley*, H. T. McDonald*, R. P. Darrell, R. M. Bond, W. B. Munroe and B. Faichney.

Directors (*from the membership at large*): E. V. Buchanan*, O. H. Scott*, O. M. Perry, R. S. Reynolds*, V. S. McIntyre*, D. B. McColl*, G. E. Chase*, R. L. Dobbin, R. S. King, J. E. B. Phelps, J. W. Peart, C. J. Moors, E. I. Sifton, P. B. Yates, T. R. C. Flint, C. E. Schwenger, M. W. Rodgers, A. B. Scott, J. E. Skidmore, J. E. Brown, H. G. Hall, E. J. Stapleton, A. L. Farquharson, T. W. Brackinreid, J. R. McLinden, H. F. Shearer, G. F. Shreve, A. H. R. Thomas, E. P. Cox, W. E. Reesor, A. B. Manson, W. G. Breen, C. A. Walters, R. H. Staford, C. H. Denton, J. B. Kelly, W. D. Stalker, E. R. Smith and Jas. D. Grant.

District Directors:—

Niagara District: A. B. Manson*, P. B. Yates*, H. F. Shearer, A. B. Scott, R. S. Reynolds, W. H. Childs, H. J. MacTavish, Geo. Grosz, J. W. Peart, R. Thomson, V. A. McKillop, J. G. Archibald, H. G. Hall, J. B. Draper, O. M. Perry, E. V. Buchanan, E. I. Sifton, J. E. Teckoe, A. E. Rumble, D. B. McColl and V. S. McIntyre.

Georgian Bay District: R. S. King*, J. R. McLinden* and C. E. Brown*.

Central District: G. E. Chase, R. O. Quick*, C. A. Walters*, E. R. Smithrim, W. E. Reesor, G. F. Shreve and W. Tait.

Northern District: C. J. Moors*.

Eastern District: M. W. Rodgers*, J. D. Grant*, R. J. Smith and A. L. Farquharson.

THE

BULLETIN

Published by

HYDRO-ELECTRIC POWER COMMISSION
of Ontario

620 University Ave.
Toronto

Subscription Price $2.00
Per Year

The Distribution of Thunderstorms *and* The Frequency of Lightning Flashes

From a Review by R. Ruedy, Division of Research Information, National Research Council, Ottawa, Canada.

THE protection of transmission lines against injuries caused by lightning may be obtained in two ways. In the first place the line is so constructed that it is able to withstand voltages six to seven times the normal value, care being taken at the same time that over-voltages of this order are not likely to build up along the supports.

On the other hand damage due to lightning might be kept down by avoiding building transmission lines in regions or spots frequently struck by lightning, or in the preferred seat, or path, of thunderstorms. In order to follow this policy, accurate knowledge of the distribution of thunderstorms in the region is necessary.

It is customary to distinguish two types of thunderstorms, the cyclonic storm which is due to the encounter, in a region of low pressure, of winds from nearly opposite directions, offering, therefore, sharp contrasts in temperature and humidity, and the heat or local thunderstorm which is due to the more rapid rate of heating of the moist air layers near the ground as compared to the rate obtaining at greater heights. In reality it is not aways possible to distinguish sharply between the two types. But it is to be expected that where there is a definite path which barometric depressions follow in traversing a country, thunder and lightning may be evenly distributed over a great distance provided the warmer wind is laden with moisture. Local or heat thunderstorms are most pronounced where during the forenoon the heating of the soil is quite rapid so that an exchange by diffusion and turbulent mixing with the colder higher layers is unable to prevent the development of two unstable masses of air. Contrasts of this kind may develop daily in tropical regions. In more temperate latitudes local thunderstorms are pronounced during the summer

CONTENTS

Vol. XX **No. 12**

DECEMBER, 1933

wherever the lower layers are hindered from escaping sideways or where their path is determined by the relief, as is the case in mountain regions. Despite their frequent occurrence the mechanism of heat thunderstorms is little known. That the influence of the earth's relief enters even into the formation of cyclonic thunderstorms is indicated by the rapid decrease in the number of storms when the depression passes out over the Atlantic Ocean. Extended flat regions are quite generally the seat of a smaller number of storms as compared with surroundings in which the relief is more pronounced.

Regional Distribution of Thunderstorms

Very detailed observations on the frequency of thunderstorms in a country have been collected by the Prussian Meteorological Service. For the 10 years from 1901 to 1910 each station immediately reported the time of the first and last thunderclap. (The range over which the thunder is heard amounts to not more than about 10 miles). By plotting this information upon maps it was possible to ascertain the place of origin of a storm, its extent at a certain time (isobronts) and direction of travel throughout Prussia, a country which presents a variety of topographical features. The districts where thunderstorms occur most often were then ascertained.

It was found that the regions where thunderstorms are frequent vary from month to month. In flat troughs located in mountainous regions, thunderstorms are frequent early in May, and the same applies to regions in which there are marked contrasts between hills and valleys. Beginning with June, owing perhaps to the increased strength of the valley breezes, the flat lowlands enter more and more distinctly into the picture; they are particularly favoured during August. When, however, the year is averaged, the number of thunderstorms in the flat and in the hilly region is practically the same, showing that the main effect consists in the rate of increase of the number of storms being higher in hilly than in flat regions, perhaps with the exception of zones which are heavily flooded in spring. Along the coast thunderstorms become frequent only in July and August.

The contrast in the number of storms occurring in plains and mountains also appears when the part of the day during which thunderstorms develop is considered.

In the case of mountain regions the thunderstorms occur more frequently on the leeward slope of the chain, the

slope along which the cold winds descend, and they reach their greatest strength along this slope, but not near the summit. It is possible that the wind brushing over the top exerts a sucking action and draws warm air along the slope and over the top wherever the contours of the hills are favourable.

The connection between cyclonic activity and the frequency of thunderstorms is, on the whole, quite pronounced throughout Prussia as shown by the direction of the storms. While it is possible to pick out areas of about 1,000 sq. miles, mountainous regions in which deep broad river valleys have been cut, and plains with extended water areas, as forming the favoured seats of thunderstorms, similar areas in other parts of the country may have as few thunderstorms as districts in which the relief is not pronounced. There is little doubt that the zones to which the greatest numbers are credited lie close to the path of the most frequent cyclonic storms, and probably enhance the effects rather than cause the formation of storms except where their physical features tend to create striking contrasts in humidity and temperature.

The collection of these thunderstorm observations proved to be of practical value. If the main paths followed by thunderstorms are drawn upon a map with a length representing the average total trajectory, then regions may be found where thunderstorms are unlikely to occur.

Moreover, because in western Europe the most frequent direction of the storm is from west to east, arrangements can be made with meteorological observatories to have storm warnings sent to all the power stations whenever conditions in a cyclone indicate the likelihood of lightning and thunder. Such a service is reliable only where information regarding conditions not only on the ground, but also in the higher atmosphere is collected at the same time, for the guidance of fliers, for instance. The meteorological service of Thuringia (Thuringer Landeswetterwarte Weimar), has established a continuous service for airplanes and power stations. As soon as, in its opinion, a thunderstorm breaks out in a district, all the power-stations are provided with information regarding the probable strength, time, duration and path of the storm. This thunderstorm service was put into operation in the summer of 1928.

A similar thunderstorm service is now functioning in Japan. The Tokyo Electric Co., and other power undertakings, furnishing together a peakload of 620,000 kw., for the larger part hydro-electric power, distributed from a net of 3,000 miles of high tension lines covering an area of 30,000 sq. miles, organized, in 1929, 219 observation posts manned by their own employees. Placed at a distance of about 121 miles from one another, they inform the meteorological service of any threatening thunderstorm. The method proved to be practical; it reduced the number and duration of total interruptions and showed that almost four-fifths of the thunderstorms observed during the summer months of 1930 and 1931 proceed from the neighbourhood of 10 different localities. About 60 per cent. of the storms have

their origin in the system of winds accompanying a depression.

Observations regarding the distribution of thunderstorms have also been made for Ohio, but during the year 1917 only. About 830 well-scattered observers were enlisted to cover the territory of 41,000 sq. miles. During this year 165 thunderstorms were reported. On seven days the storms were general over the state, on 11, over almost the whole state, on 23 half the state was visited by storms and on 17 almost half. Sudden decided changes in weather proved to favour the formation and growth of storms. Of the 37 instances of the passage of squall-lines of Alberta lows, 35 produced thunderstorms in Ohio. The openness of the state both to warm moist winds and to cold dry winds provides favourable conditions for the formation of thunderstorms. The greater number of the storms (85 per cent.) are due to general meteorological conditions affecting large portions of the country.

The Frequency of Lightning Flashes

The earth's relief, the conductivity of the air, geological formations and accidents, and the presence of ground water have been claimed as decisive factors influencing the frequency of lightning flashes at a given point.

(*a*) *The earth's relief*

The influence of the relief is undoubted; the highest points within a region are quite generally considered to be most dangerous, and the violence of thunderstorms in mountain regions is well known. Parties overtaken by thunderstorms are obliged to throw away their pick-axes when the metal parts start to buzz and discharge. In a recent attempt to climb Mount Waddington in the British Columbia Coast Range, a party had to retreat before a threatening storm at over 12,000 feet altitude. "The brush discharge turned points of rock to blue torches", and "ice axes in their owner's hands flamed for two hours" before the refuge was reached.

The thunderstorms in the southern Alps and other mountain ranges are noted for the large number of lightning flashes toward the southern and southwestern horizon during very violent storms; over 1,000 flashes may be counted within a quarter of an hour.

Moreover, the number of storms increases with the approach to mountain ranges, but decreases again once the first few chains have been crossed: points along the foot of the Alps have 18 to 22 thunderstorms each year; in the valley of the Rhone and its tributaries, the number falls to 3, the total amount of rain decreasing in the same manner. Similar conditions are found along the British Columbia coast.

The reason why mountain storms may become highly dangerous is, of course, the short distance between the highly charged space which is the seat of the clouds and the higher summits which are near zero potential. In the same way winter thunderstorms sometimes seem to become quite dangerous on account of the low altitude of the clouds at that period of the year. Where the mountains form sharp needles or horns the electricity may leak off in the form of a luminous point discharge (wrongly

called St. Elmo's fire) producing a strong hissing sound which increases in pitch with the strength of the discharge. When the strength has reached a certain point a lightning flash is produced.

In low lying country thunderstorms originate between the altitudes of 500 and 3,500 feet. In the Austrian Alps and in the mountains of the Near East the limit is about 12,000 feet so that only the highest peaks are never exposed to a thunderstorm.

(*b*) *Conductivity of the air*

According to C. Dauzere, Director of the Observatory on the Pic du Midi in the Pyrenees, when a storm approaches there is an increase in the number of atmospheric ions, especially those which are negative. Numerous measurements of the conductivity of the air have been made by C. Dauzere and J. Bouget in districts reputed to be frequent marks of lightning flashes. These surveys are said to have shown, first, that the total conductivity of the air is permanently at a maximum at spots often hit by lightning and, second, that this high conductivity results from an exceptional abundance of negative ions of ordinary mass. In spots never struck by lightning within living memory the total conductivity lies between 1.5×10^{-4} and 2.5×10^{-4} e.s.u. In zones where lightning strikes frequently the conductivity is above 3×10^{-4} e.s.u.

These results have been confirmed by Bogoiavlensky when studying two districts 125 miles from Leningrad, which according to an investigation carried out in Leningrad are places frequently hit by lightning.

In the two regions thus examined, the ground is formed by sedimentary rocks of Devonian origin, sandstones and clays overlain by glacial material, crystalline rocks coming from Finland. It is assumed that these rocks contain radio-active deposits, and that differences in their concentration are responsible for the variations in the conductivity of the air near the ground, differences to which the lightning flashes are sensitive.

In a third district where granite underlies alluvium a power line is often struck over a length of four miles, the wood posts suffering serious damage. Here again, points of damage coincide with points of maximum ionization.

(*c*) *Underground water*

In a recent survey made in Saxony (Germany) lightning flashes hitting the country's 100 kv. and 30 kv. transmission lines were found to fall most frequently upon points along the foot of the mountain slope, in particular within a section four miles long, between the cities of Dresden and Chemnitz. The rest of the 50-mile stretch between these points was practically immune, though in 1925 the reverse was true. The 300 miles of 100 kv. line traversing the lower region of Saxony was hardly ever hit by lightning between the years 1923 and 1931. The dangerous section passes 40 metres below the highest point of the Saxon Ore Mountains (Erzgebirge) over barren ground. The soil in the mountains is formed by so-called mica-slate which carries quartz and is a very bad conductor. It is covered with only a very thin layer of humus, which however

supports tree growth even in the higher parts of the range.

By employing the services of a dowser, it was possible to show that the hits occurred where subsurface water currents crossed or came near the line. The findings were confirmed by drilling 18 holes in spots which the divining rod had indicated as the seat of underground water currents. Water was met in all these cases at depths from between 4 to 9 metres. Unfortunately no drillings were made in order to find out whether water was not also present in places where the line was safe from lightning. Moreover, after the tower footing resistance had been reduced from 80, or as much as 250 ohms in one case, to a low value by sticking iron tubes from the foot of the tower into the ground water, the number of injurious flashes hitting the line dropped from 12 in 1930 to zero in 1931, despite the passage of at least 25 thunderstorms across the region. Where the masts were found set into the bare rock, earth cables were laid from tower to tower. In this discovery of the causes leading to the crowding of lightning flashes into narrow sections it is seen that the number of flashes hitting the line may in reality have been fairly even throughout its length.

It is worth adding that the potential differences and the electric conductivity above the underground water veins were found to be above the values possessed by average surfaces. When, however, a strong wind was blowing no difference could be detected. A patent on this new method of detecting ground water surfaces was applied for.

Even more conducting paths in the ground than water veins do not attract lightning; this is shown by the damage done to the telephone cable Austria-Switzerland, which was struck on July 6, 1929, and again on August 18 of the same year at a point three-quarters of a mile from the first. On July 6, the lightning flash first hit into a rocky mountain-side 150 metres from the cable; a current descended over the slope of gravel covered with a thin layer of soil, opening a channel down to the rock. On August 18, the flash struck 40 meters above the cable into an abrupt wall of rock; then a current passed down the slope, crossed the main road which is 8 metres wide, removing a strip of asphalt cover 0.2 to 0.6 metre wide, and escaped by way of the cable. The cable was buried in the alluvial deposits of the river in fairly well conducting ground.

In order to decide whether one region is more frequently hit by lightning than another, it is necessary to count not only the strokes which cause damage, but also those leaving no trace along the transmission line, otherwise the statements have no more value than the popular view that one kind of tree (oak) is more often hit than another (beech). If a careful survey were made, it would probably show that, other things being equal, beeches are struck just as often, but are able to lead the current into the ground, whereas oaks, owing perhaps to the uneven dry outer bark along trunk and root most often suffer serious damage.

The question whether water running on, or below, the surface of the earth attracts lightning has been investigated by Professor A. Schwaiger,

Munich Institute of Technology, Bavaria, at the request of the Insurance Department of that country.

The investigation was limited to laboratory tests, the clouds being represented by charged metallic spheres, the water courses by cylindrical rods, suspended in a non-conducting medium (air), or buried in dry or moist sand, half a centimeter below the surface.

The conclusions drawn were that the lightning flash hits the water (cylindrical electrode) when the surroundings are non-conducting; places where two rivers join are hit when the flash starts at the cloud. When the ground in which the river flows is very moist, lightning strikes in a hit-and-miss way the ground or the river, but seems to avoid junctions.

Little weight should be placed upon results obtained in this way, as no thought was given to reproduce conditions in the laboratory true to scale.

Many herbaceous crops, including potatoes, tobacco, cotton, sugar beets, kale (Brassica oleracea variety), alfalfa, ginseng, onion, tomato, and cucumber have been reported as being injured by lightning. In general the damaged areas are sharply delimited although the margins are somewhat ragged and there is a narrow zone of weakened plants. In general the area struck by lightning is roughly circular in outline, the diameter varying from 10 to 30 feet. Where much larger surfaces are involved, the distribution of the damage is probably associated with the presence of surface water, in furrows, for instance. Within the affected spot the plants may look as if they had been flattened out, whereas the remainder of the field is quite as usual. The stalks of potato plants bend, usually at the surface of the ground, but sometimes along the stem so that the plants droop or lie upon the ground; there may also be some splitting of the stalks. The leaves and shoots seem to suffer less heavily. No disturbance of the soil is noted as a general rule. It seems that injuries of this kind can be observed year after year in Pennsylvania, New Jersey, Michigan and Wisconsin. Certain plant pests, however, may produce damage of the same general aspect so that the cause must be ascertained in each case. Where the effect is due to plant disease the damage does not appear suddenly, and there are likely to be quite a few healthy stalks scattered through the infested area.

Thunderstorm statistics compiled by the British Air Ministry indicate that the average number of thunderstorms in progress at any one instant in all parts of the world reaches a total of 1,800. The number of separate lightning flashes is estimated at about one hundred a second. Brooks in 1925 came to the conclusion that 44,000 thunderstorms break out on the earth during the average day. The damage done on earth by lightning flashes is certainly not comparable to their great number, and we cannot help thinking that where man has not interfered, most of the flashes are harmless. It is known that despite the frequent thunderstorms in tropical regions where vegetation and soil are rich in moisture, little injury is produced by lightning flashes.

Lightning Investigations in the Rocky Mountains

While the damage done to herba-

ceous plants is limited to the small area actually struck, lightning striking forests is apt to start disastrous fires in a great number of cases, if we accept the findings of the Northern Rocky Mountains Forest Experiment Station, Missoula, Montana. According to the reports furnished by lookout men stationed on about 270 mountain tops scattered over an area of 23,000,000 acres of federal forest land in northern Idaho and western Montana, lightning is to be credited with an average of 824 fires each year during the 10-year period 1919 to 1928, although the average number of storm-days affecting the whole region may be estimated at not over 90.

To investigate the occurrence of zones preferred by lightning, the locations of several thousand lightning fires in the northern Rocky mountain region were plotted on maps, but although these maps show conditions for more than 10 years, there is a baffling scattering of these fires which renders the problem difficult. These maps, of course, show merely the occurrence of lightning-caused fires, the fires often being due to the presence of cut wood and therefore do not reveal all the points struck by lightning, but in view of the large number of observations any tendency to strike narrow zones ought to have become pronounced. There was no evidence that lightning fires occur in zones limited by altitude; but this may be due to the storms travelling over considerable stretches, growing and decreasing as they progress. They are apparently cyclonic storms; 62 per cent. of all thunderstorms move toward the northeast and east, and 86 per cent. between north and southeast. One-fourth of the storms are first seen before noon.

Geological Conditions in the Neighbourhood of Ottawa

There are a great many places in Canada which, according to the findings of Dauzere and his followers, ought to attract lightning, i.e., contacts between different rocks and faults. The road from Kingston northeasterly along the west side of the Rideau canal lies on rocks of bedded limestone of Ordovician age, which ought to be nearly lightning-proof. After about 5 miles, the road descends a steep hill which forms a cliff-like margin to the old bed of the Rideau River which was incised along the contact of the Ordovician with the Pre-Cambrian floor of granite as seen near Kingston Mills. This region, in particular the contact surface, ought to be the playground of frequent lightning flashes. The neighbourhood of Barriefield, 1.7 miles from Kingston, where Ordovician limestone, a granite dyke of Laurentian age and gneisses are exposed, ought to prove a favourite mark for lightning flashes.

Ottawa lies in a lightning-safe region, underlain by Trenton limestone (Ordovician) in the north and west parts of the city and 400 feet of Utica shale to the east and southeast. The only dangerous feature is the Hull and Gloucester fault which starting near Rigaud runs west to Ottawa for a distance of 65 miles, then curves toward the north, crosses the Ottawa River near the Chaudiere Rapids, and the Gatineau River about Ironsides, with Black River limestone west of the fault, and still farther west the

Chazy series, all Ordovician sediments.

The regions north and south of Ottawa are of particular interest because of the presence of the high voltage transmission lines of the Ontario Hydro-Electric Power Commission. Of these the line from Ottawa over Smiths Falls to Kingston would be on safe ground according to Dauzere's views except for the section crossing Frontenac county, where it stands on Pre-Cambrian rocks. The line from Chats Falls to Toronto, on the contrary, would have to be considered as on dangerous ground throughout Lanark, Frontenac, Lennox and Hastings counties where granitic and gneissic rocks cover extended areas. It is here suggested, however, that if differences actually occur, they may be due to the higher electrical and contact resistance of the ground, and not to higher conductivity of the air close to the ground.

Constitution of the Lightning Flash

As shown by H. Kayser in 1884, the lightning flash consists in many cases of a number of successive discharges which follow one after another at short intervals. By means of a rotating camera B. Walter in Hamburg first succeeded in determining the total time of a flash consisting of five strokes as equal to 0.245 second, the time separating the discharges being 0.036; 0.036; 0.028 and 0.144 sec., respectively. In another case three discharges took place, the second 0.018 sec. after the first, and the third 0.049 sec. after the second. The first partial discharge did not reach the earth, the second reached the earth at a distance of 5 km. from the camera, the third took an almost entirely new path, making a sudden turn in the lower part of the former course and ending upon a neighbouring cloud. Another flash photographed during the same half-hour (May 30, 1902) had two components with 0.023 sec. between them, both ending in the earth's surface, over one km. apart. Each component showed a number of side-branches, which, however, were unable to reach the ground. Sometimes a subsequent flash follows the direction of a former side-branch which was unable to complete its course. It seems as if the growth of the side-branches were influenced by charges in the neighbouring clouds, not by conditions on the ground. In other cases the side-branches are reproduced, though with falling strength, by each flash which follows.

The Thermal Method of Fault Location on Underground Cables

By Jas. R. Smith, Asst. Engineer, Distribution Section, Electrical Engineering Dept., H.E.P.C. of Ont.

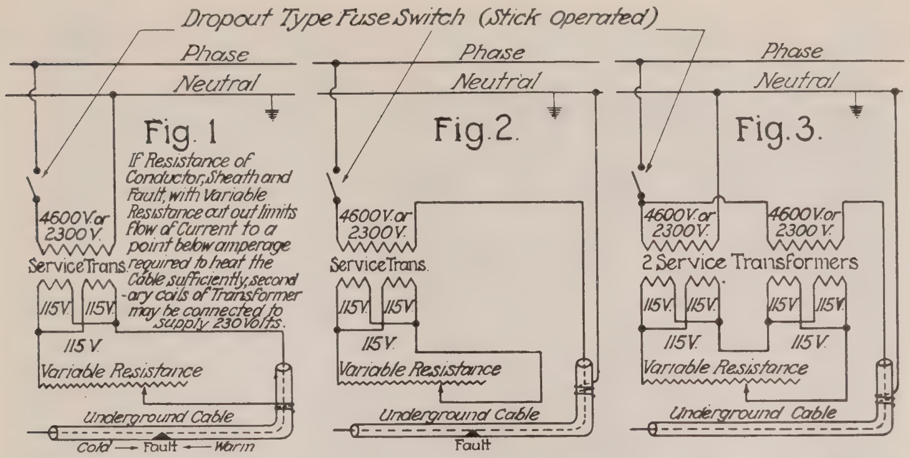
SINCE underground cables have been used for the transmission and distribution of electrical energy, various methods of locating faults have been evolved. Of these, probably the simplest and least technical is that recently originated by the writer in locating trouble in the Barrie Rural Power District on a two conductor No. 8 B. & S., paper insulated, lead covered cable buried directly in the earth for the supply of single-phase, 4,600-volt service.

All usual methods of fault location were ineffective due to the fact that a lightning discharge on the overhead system supplying the underground cable had punctured the insulation at various points allowing current to go to ground through several high resistance paths, simultaneously. When this condition was recognized the thought presented itself of passing current through the conductors, faults, and sheath, in sufficient quantity to raise the temperature of the lead sheath to a degree considerably above that of the earth in which it was buried.

This was accomplished with very little difficulty by using materials readily obtainable from rural distribution stores. A standard 15 kv-a. service transformer was connected as shown in Fig. 1 to supply limited current at low voltage to the faults. By digging test holes and exposing approximately a foot of cable to permit circulation of air around the sheath it was possible to distinguish between the section of cable which was carrying current from the point of supply to the faults and that which was not being energized beyond the faults.

At a later date in Lynden rural power district a single conductor No. 6 B. & S., rubber insulated, lead covered, grounded, single-phase, 2,300-volt distribution cable, approximately one mile long, buried directly in the earth developed a fault which could not be located by the usual methods. Due to unusual conditions in the district variable ground currents were found to be carried on portions of the cable sheath. Similarly, in Saltfleet rural power district one of the three No. 4 B. & S., single conductor, rubber insulated, lead covered cables, approximately one and one-quarter miles long, buried directly in the earth to a minimum depth of 18 inches and carrying 3-phase, 4,000-volt current broke down in service. Because of stray ground currents and the close proximity of the other two cables the ordinary fault-finding equipment proved to be useless. In both these instances the thermal method of fault location was finally resorted to and successfully applied, the fault being found approximately five-eighths of a mile from point of test in the former and one mile in the latter.

These and other tests proved that it is possible to find trouble in and distinguish a faulty cable from other similar cables by comparing the



Connections to Supply limited Current at low Voltage to Fault

Connections to Supply limited Current at line Voltage to Fault or Re-establish Fault

Connections to Test Cable at double line Voltage or Re-establish Fault

temperature of the section of the cable where current is flowing with the section beyond the fault, which gives no indication of rise in temperature. It was found that a very slight difference can be readily distinguished by touching the cable sheath with the hand. This is particularly true of lead covered cables buried directly in the earth where it is only necessary to take the chill off the sheath to recognize the difference in temperature. Also due to the more rapid evaporation of moisture on the current carrying sheath the latter gives a visual indication due to change in colour.

Usually when a fault occurs in service there is considerable arcing and often the conductors are short circuited to the sheath at the point of breakdown. It is then only necessary to make the connections shown in Fig. 1.

If, however, the trouble is such that low voltage will not flow through the fault or if the low voltage will not maintain the circuit, then the fault should be re-established as shown in Fig. 2. When this has been done the cable should be reconnected as shown in Fig. 1. Repeated tests show that once the low voltage circuit is established the tendency is for the fault resistance to decrease. It would appear that at the fault the molten metals flow together just after the arc is quenched.

In rare instances a cable will break down in service and the fault will be cleared so that line voltage may be again applied without further breakdown until a surge or moisture re-establishes the trouble. To break down the fault in such cases double line voltage should be applied as shown in Fig. 3 followed by line voltage Fig. 2 and finally low voltage Fig. 1.

The low voltage fault current may be measured by means of a tong type or other ammeter in the secondary circuit. To obtain approximate primary current divide secondary current

Fig. 4—Equipment originally used in Dundas rural power district to locate faults by the thermal method.

by ratio of primary to secondary of transformer.

A comparatively accurate idea of where a fault is located may be obtained by noting the amount of resistance in circuit when a given amperage is flowing in a cable the characteristics of which are known. Thus very few test holes are required and considerable time is saved in locating the fault. Care should be exercised to avoid heating the cable above its safe operating temperature as determined by specifications of cable under test. In practice it has been found that a temperature well below this value is all that is required. A smaller amount of current than would be expected is required to produce the necessary temperature because of the fact that usually the sheaths of cables are of greater resistance than the cores thereof.

To test the cable at double line voltage after repairs have been made the connections shown in Fig. 3 may be used. In the event of the transformers being of different polarities either the primary or secondary connections of either transformer should be reversed in Fig. 3. Otherwise one transformer will neutralize the effect of the other.

The photograph marked Fig. 4 shows connections and equipment originally used for locating faults by the thermal method, and that marked Fig. 5 is a picture of the actual apparatus now adopted in Dundas rural power district.

All cables used for connections should be insulated to provide an adequate factor of safety for maximum voltages applied thereto. Transformer cases and other non-current carrying metal parts must be adequately grounded. In the event of testing apparatus being used on a truck the frame thereof and any isolated metal parts in contact with test equipment should also be properly grounded. Warning signs

Fig. 5—Apparatus adopted in Dundas rural power district.

should be prominently displayed and every possible precaution taken to avoid accidents.

It is hoped that this simple method which eliminates all calculations and the use of complicated fault finding apparatus will prove of value where-ever underground cables are used for the transmission and distribution of electrical energy. As little practical application has been made of this idea to date, all those using it should add to the sum of knowledge by recording suggested improvements, and the results of tests.

* * * *

The co-operation of Superintendent H. Tideman and field staff of Barrie rural power district when original trials were made, and the assistance given by Supt. T. A. Scott and field staff of Dundas rural power district when further tests were carried out, is gratefully acknowledged.

O.M.E.A. and A.M.E.U. CONVENTION

at King Edward Hotel, Toronto

January 31 and February 1, 1934

Fluorescence

By F. K. Dalton, Testing Engineer, H.E.P.C. of Ont.

FLUORESCENCE is a property exhibited by some materials such that when excited by light rays, ultra-violet or X-rays, they emit rays of other wave lengths than those by which the substances are being excited. The observed phenomenon often is very spectacular, but the reason is not clearly known, nor can it be determined beforehand just what the response of any particular specimen will be.

According to the rule, the secondary rays are of longer wave length (lower frequency) than the primary, or exciting rays. Thus a blue light may excite a particular specimen to appear red or yellow, rather than blue, and invisible rays, such as ultra-violet or X-rays, will induce certain substances to emit visible light, which may be of any colour in the spectrum.

Probably the most practical application of fluorescence is in the X-ray viewing screen, where the invisible penetrating rays cause a responsive salt on the screen to emit a yellowish green light, having intensity varying with that of the X-rays, and thus producing a visible image of the opaque object, and its contents, placed before the screen.

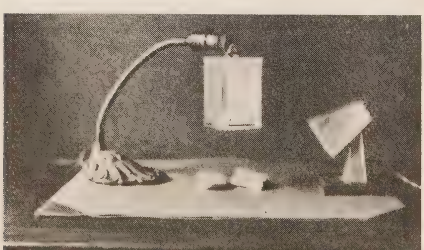


Fig. 1—The Argon Bulb Ultra-violet Lamp set up for examination of specimens, shown beneath it. To the right, a hood containing an incandescent lamp for ordinary illumination.

Fig. 2—Specimens fluorescing under the Ultra-violet Lamp. To the eye, the specimens only are visible; the other illumination is not seen. This photograph was produced,—both taken and printed,—by invisible ultra-violet rays.

Another application is in the examination of minerals, ores and gems, under ultra-violet rays for purposes of identification, detection of impurities and classification as to place of origin, in which this method has the advantage that the specimen is not disturbed, or in any way damaged, by the test.

The most commonly known instance of fluorescence, however, is that exhibited by the earth's crust, and all other known substances, which when excited by the sun's rays, emit heat, i.e., infra-red rays that are of longer wave length than light. That the result is due to fluorescence is very clearly apparent in this case when one considers that the sun's heat rays cannot penetrate the frigid vacuum of celestial space.

A new application of fluorescence, as yet a comparatively unexplored

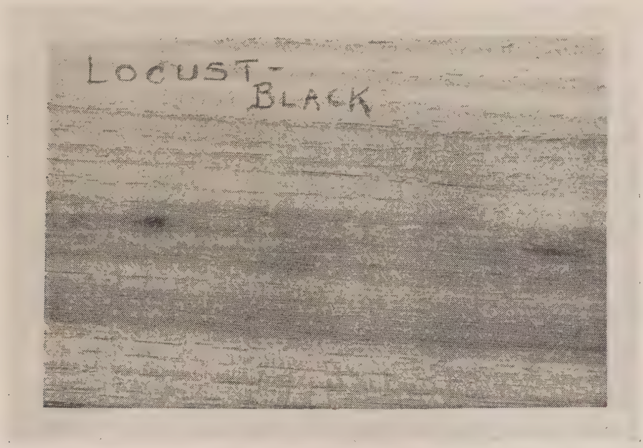


Fig. 3—A specimen of Black Locust wood in daylight. The darker central part is heartwood: the lighter parts on each side are sapwood.

Fig. 4—The same specimen of Black Locust as it appears under ultra-violet rays. Only the heartwood is visible, giving a bright yellowish green fluorescence: the strips of sapwood do not fluoresce and therefore cannot be seen.

field and one which should prove most interesting, is the use of ultra-violet rays on wood. During the writer's experiments with the new Argon ultra-violet glow lamps, and suitable light-suppressing filters, a large number of wood specimens were found to possess very definite fluorescent features. In practically all instances, the fluorescence was of a yellowish green colour. Some specimens were very brilliant,—Black Locust (U. S. A.) and Keriti Silverballi (British Guiana) being the most striking. In other cases, Sumach and Smoke Tree, the grain, or flower, of the wood was much more prominent than when observed by daylight,

while in still other specimens small spots appeared, probably being resin, as in Western Yellow Pine.

The accompanying list gives the common names of the woods which were found to fluoresce,—approximately ten per cent. of the total number of specimens in the writer's world-wide collection of the most important woods. It would appear that the phenomenon is not confined to woods from any particular part of the world; in fact, such woods as Satinwood, from different parts, respond in closely similar manner.

The advantages in this use of fluorescence are not yet fully apparent. It may provide a reliable method of identifying woods, of determining the age of the tree from which a particular specimen has been cut, or of detecting impurities or imperfections, and thus would serve as a guide in the selection of timber.

As examples here, a specimen stated to be Cottonwood is identified as Basswood by fluorescence alone; a specimen from an older tree may be less responsive than one from a sapling; weaknesses due to grain may be detected. Fluorescence introduces a quick method for comparing a sample of wood, or any part of the sample, with a standard specimen.

These are a few uses of fluorescence but with the less expensive sources of ultra-violet rays which are now available, still more applications are likely to be found wherein the "unseen light" will render apparent many features which daylight cannot reveal, and then that which is hidden in the unexplored fields will become part of the new scheme of things.

FLUORESCENT WOODS

Specimens Fluoresce under Ultra-violet Rays

Practically all Fluorescence is of a Yellowish Green Colour.

Canada
Western Yellow Pine (Spots), White Poplar, Papaw, Sumach, Ailanthus, Mulberry (Sap wood only), Basswood.

U.S.A.
Holly, Orange, Smoke Tree, Catalpa, Black Locust (Heartwood only).

Mexico
Matabuey, Zapotillo.

Jamaica
Guava, Lignum Vitae (Sap wood only), Guinep, Satinwood.

British Guiana
Yaruru, Silverballi—Keriti Silverballi—Yellow.

Brazil
Pau Marfin, Peroba, Jataby, Faveiro, Guatambu.

Argentina
Virapita, Quina, Lanza, Viraro, Pacuri, Quebracho, Urundel.

England
Lime.

Portugal
Cork Oak (bark only).

India
Sit, Siris, Black Siris, Haldu, Brown Padauk, Ebony (D. Assimilis), Satinwood, Acacia Arabica, Mulberry, Chooi, Papita.

Palestine
Terebinth, Gophir.

Borneo
Merabau.

Australia
Red Mountain Ash, Spearwood, Wattle.

NIGERIA
Ayinre.
SOUTH AFRICA
Kamassi.
VENEERS
Satinwood, Poplar (burl), Moire Ash, Rosewood, Tulipwood, Gonzalo Alvez, Blackwood, Zebra, Bubinga.

Cold Light

Luminescence is the term applied to all light produced except by incandescence. "Cold light", as luminescence is popularly called, has many different sources—the fascinating fire fly being the best known. The intermittent flashes of light produced by the fire fly is an example of zoological luminescence, of which there are endless numbers in the animal world—such as the several varieties of glow worms, and numberless marine animals, particularly among deep-sea life. Exactly how this light is produced is unknown, although it is quite definitely thought to be the result of an oxidation process.

Other kinds are well known: electroluminescence produced by the passage of electricity through gases, corona, glow-discharges, cathode-glows and the like; chemiluminescence, the light produced from decaying vegetable matter—often seen in the woods at night and commonly called fox fire; triboluminescence, the light produced by some substances, calcium chloride for example, when under pressure or when rubbed; photoluminescence, the light produced by some substances when under the influence of rays in the visible spectrum. Some substances exhibit photoluminescence only so long as the exciting rays are present, this kind of luminescence being called fluorescence. If the phenomenon continues for a time after the light has been taken away it is called phosphorescence.

Nearly all substances transform the energy received in the form of light into heat-energy with wave lengths far longer than that of the energy of the light. However, practically all substances transform an insignificant amount into energy with wave lengths in the visible spectrum. A few substances transform a substantial part of the light energy received into light energy of a different color—enough to be readily visible. These are said to be fluorescent or phosphorescent substances depending upon whether they continue to give light after the exciting light is removed.

A most common instance of photoluminescence is the so-called "radium" dial on watches and clocks. The figure are painted with a chemical that continues to give off the familiar greenish light long enough after the exciting light is removed to make the figures distinguishable throughout the night. A "radium" dial kept continually in the dark would finally cease to phosphoresce.

—*The Electric Journal.*

Darkness Brings Death
On Our Urban Streets and Rural Highways

By Osborne S. Mitchell, Editor, Electrical News and Engineering

PROVING THAT . . . .

1. *41 per cent. of all motor vehicle accidents occurring after dark can be traced to inadequate lighting of city streets and rural highways.*
2. *On rural highways where there is no lighting, 50 per cent. of night time motor vehicle accidents are due to poor visibility.*
3. *Fatalities increase considerably with darkness.*

THE time is fast approaching when we must seriously consider lighting some of our more travelled highways, for this method appears to be the only way in which we can materially decrease highway accidents—unless, of course, we prohibit the use of highways after dark.

For many years various safety leagues and associations, in conjunction with municipal and provincial governments, have disseminated publicity by various means to persuade motorists to drive safely. This work no doubt has had good effect and while we would not like to see it discontinued, the percentage of accidents to licensed vehicles appears to remain fairly constant. On the other hand it is obvious that while through adequate propaganda it is possible to somewhat diminish accidents, for instance at railway crossings, is it not better to entirely eliminate the hazard by removing it? After making a searching investigation into the various hazards causing motor vehicle accidents, it appears to be quite clear that *darkness, or inadequate illumination, is one of the greatest of hazards and is responsible for more accidents and more deaths on our highways than perhaps any other one factor.* Why not remove it?

Unfortunately, we are unable to present complete statistics on motor vehicle accidents for the whole Dominion, as figures are not available for each province, but we are able to present an analysis of the figures collected by the Motor Vehicle Branch of the Department of Highways of Ontario. The statistics kept by this department are very complete and from them we can deduce many important facts, the most startling being *that about one-half the accidents occurring after dark can be directly traced to poor visibility.*

In order to ascertain the responsibility of inadequate illumination for night-time accidents, we have prepared a graph showing the hourly distribution of all motor vehicle accidents throughout Ontario during two three-month periods. Accidents for the summer season, May, June, and July are compared with those which occurred during the winter season, January, November and December. It will be noted that the number of accidents for these two periods (Tables I and II) happens to be about the same, 2,332 occurred in the three-month summer season, and 2,371 during the three-month winter season.

From 12 midnight up to around 5 p.m., and again after 8 p.m., the chart shows that although the difference is

TABLE I

TOTAL MOTOR VEHICLE ACCIDENTS DURING THREE SUMMER MONTHS IN ONTARIO—1932.

Hour of Occurrence	May	June	July
12 to 1 A.M.	15	23	27
1 to 2 A.M.	15	19	19
2 to 3 A.M.	17	18	31
3 to 4 A.M.	6	7	6
4 to 5 A.M.	4	4	9
5 to 6 A.M.	4	2	8
6 to 7 A.M.	2	8	6
7 to 8 A.M.	11	11	18
8 to 9 A.M.	19	24	32
9 to 10 A.M.	19	27	23
10 to 11 A.M.	22	36	42
11 to 12 A.M.	24	33	47
12 to 1 P.M.	36	39	57
1 to 2 P.M.	28	27	40
2 to 3 P.M.	33	50	56
3 to 4 P.M.	36	39	59
4 to 5 P.M.	40	63	49
5 to 6 P.M.	65	59	74
6 to 7 P.M.	43	37	57
7 to 8 P.M.	59	51	58
8 to 9 P.M.	44	50	44
9 to 10 P.M.	41	52	52
10 to 11 P.M.	37	30	48
11 to 12 P.M.	47	43	44
Not stated	4	1	2
TOTALS	671	753	908

TABLE II

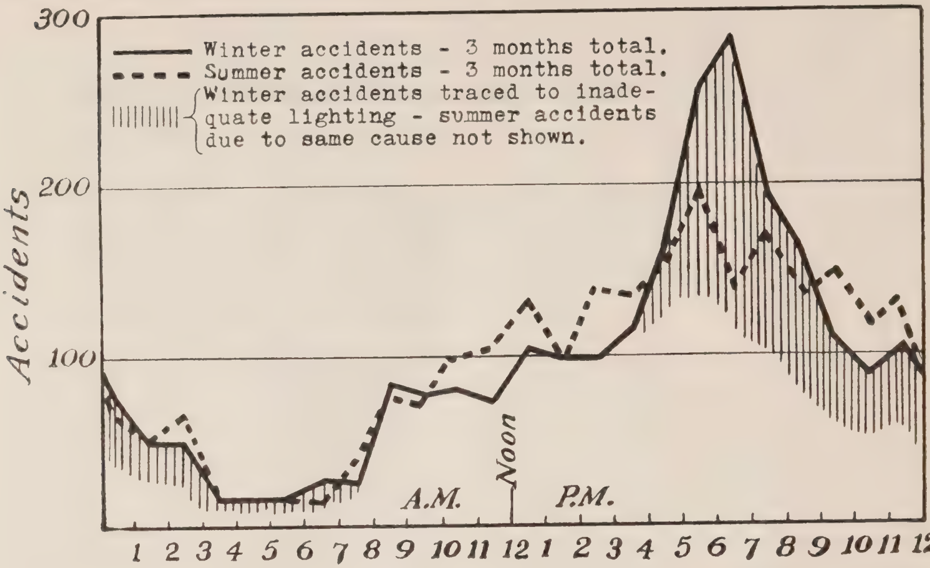
TOTAL MOTOR VEHICLE ACCIDENTS DURING THREE WINTER MONTHS IN ONTARIO—1932.

Hour of Occurrence	Jan.	Nov.	Dec.
12 to 1 A.M.	25	21	29
1 to 2 A.M.	17	15	17
2 to 3 A.M.	16	15	17
3 to 4 A.M.	6	7	6
4 to 5 A.M.	11	1	3
5 to 6 A.M.	8	5	6
6 to 7 A.M.	7	10	10
7 to 8 A.M.	3	10	12
8 to 9 A.M.	17	37	28
9 to 10 A.M.	16	31	28
10 to 11 A.M.	22	32	26
11 to 12 A.M.	25	24	26
12 to 1 P.M.	29	40	36
1 to 2 P.M.	29	26	44
2 to 3 P.M.	35	25	39
3 to 4 P.M.	46	29	41
4 to 5 P.M.	49	55	54
5 to 6 P.M.	59	97	101
6 to 7 P.M.	64	112	109
7 to 8 P.M.	57	62	77
8 to 9 P.M.	49	52	61
9 to 10 P.M.	23	28	52
10 to 11 P.M.	34	20	36
11 to 12 P.M.	31	35	40
Not stated	3	1	2
TOTALS	681	790	900

never great, winter accidents are fewer than summer accidents—due to a smaller number of vehicles on the roads. During the three-hour period from 5 p.m. to 8 p.m., there is a considerable rise (about 50 per cent.) in the number of winter accidents, even though the intensity of traffic is undoubtedly less.

Let us compare the winter and summer accidents from 9 o'clock in the evening to 5 p.m. the next day. During this period of 20 hours, the difference in average visibility between summer and winter has little effect, owing to the fact that traffic is at a minimum around dawn, when light conditions vary with the season. The comparison shows the winter total to be 87 per cent. of the summer total.

Now, if illumination had no influ-



This chart shows the seasonal difference in the hourly distribution of motor vehicle accidents in Ontario. From 9 a.m. to 4 p.m., winter accidents are fewer than summer accidents—proving that traffic is lighter in winter months. Winter accidents, however, far exceed summer accidents between the hours of 6 to 8 p.m. when it is light in summer and dark in winter. After 9 p.m. winter accidents again fall below summer accidents—proving a very much lighter traffic density.

ence on the number of accidents, this relationship should hold during the hours that are light in summer and dark in winter—that is, the hours of 6 to 8 p.m. The number of accidents during these hours in the summer season was 305, which would lead one to expect, on the basis of the above relationship, a total of 265 winter accidents in the same two-hour period. However, the winter total was actually 481, or 216 in excess of the indicated amount. *This excess, amounting to 41 per cent. of the winter accidents for this two-hour period, can justifiably be charged to insufficient illumination,* and if it holds for that period it should hold for all after-dark accidents.

More Fatal Accidents After Dark

The next point to discover is: How serious are these accidents which occur after dark? Tables III and IV shed some light upon this question. During the year 1932, there were a total of 9,171 accidents, of which 43 per cent., or 3,947, occurred after darkness had begun to fall. More significant still is the fact that the percentage of fatal accidents (in which one or more persons are killed) increases at dusk and after dark. This is also brought out in Table IV.

Pedestrian Fatalities Most Common

Analyzing still further as to the nature of these motor vehicle accidents we find (in Table V) that the most common type of accident is collision with another automobile, 3,555 (with 60 fatal) out of a total of

TABLE III

EFFECT OF LIGHT CONDITIONS ON ALL ONTARIO MOTOR VEHICLE ACCIDENTS 1932.

Light Conditions	Number of Accidents Total	Fatal	% Fatal
Daylight	5,210	235	4.5
Dusk	569	36	6.3
Dark	3,378	190	5.6
Not stated	14	..	..
TOTALS	9,171	461	..

43 per cent. of all accidents occur after darkness falls.

49 per cent. of all fatal accidents after darkness falls.

TABLE IV

TIME OF ALL ACCIDENTS—1932

Hour of Occurrence	Accidents Total	Fatal
12 to 1 A.M.	253	12
1 to 2 A.M.	201	8
2 to 3 A.M.	177	10
3 to 4 A.M.	74	3
4 to 5 A.M.	76	7
5 to 6 A.M.	62	7
6 to 7 A.M.	88	7
7 to 8 A.M.	124	6
8 to 9 A.M.	280	22
9 to 10 A.M.	262	9
10 to 11 A.M.	350	14
11 to 12 A.M.	41	101
12 to 1 P.M.	455	22
1 to 2 P.M.	396	17
2 to 3 P.M.	460	16
3 to 4 P.M.	504	28
4 to 5 P.M.	670	21
5 to 6 P.M.	871	36
6 to 7 P.M.	767	57
7 to 8 P.M.	712	44
8 to 9 P.M.	627	42
9 to 10 P.M.	493	23
10 to 11 P.M.	401	19
11 to 12 P.M.	437	20
Not stated	30	..
TOTALS	9,171	461

Fatal accidents increase with darkness and although fewer cars travel at night, the fatalities are heavier than during the daytime.

3,555. The most serious type of accident, however, is collision with pedestrians, a total of 2,826, of which 226 were fatal accidents. The third serious type of accident is the non-collision (running in ditch, etc.), accounting for 703, of which 44 were fatal accidents. All of which points to the fact that fatalities occurring on highways after dark falls make up a large and serious percentage of our total automobile accidents.

DARKNESS DOUBLES THE HAZARD

This fact is further emphasized in Table VI which gives in percentages the average traffic densities on the King's Highways (compiled from traffic studies made by Ontario Dept. of Highways) for daylight and dark. It also shows that if the density of traffic after dark had been equal to the density during the daytime, the night fatalities would have been *twice* the number of those occurring during daylight. This figure compares fairly well with our previous calculated figure—that 41 per cent. of all accidents occurring between the hours of 6 to 8 p.m. in the winter (a period of time light in summer) can be charged to inadequate lighting. We can, therefore, rightly claim that approximately *half the rural highway accidents occurring after dark are directly due to*

TABLE V

Type of Accident

Type of Accident	Total	Fatal
1. Collision with pedestrian	2,826	226
2. Collision with other automobile	3,555	60
3. Collision with horse drawn vehicle	247	7
4. Collision with R.R. train	118	35
5. Collision with street car	229	11
6. Collision with other vehicles	18	1
7. Collision with fixed object	596	34
8. Collision with bicycle	596	28
9. Collision with motorcycle	190	9
10. Non-collision accident	703	44
11. Miscellaneous	93	6
Totals	9,171	461

the driver, or drivers, not being able to see clearly.

Headlights of Little Use

It might be claimed by some that night accidents could be reduced by increasing the beam strength of motor vehicle headlights. While any increase in the strength of the beam would, no doubt, be helpful in some cases, it must be realized that this method of the motor vehicle illuminating its own path is not only scientifically wrong, but is ineffective in practice. It is well known that the ability to see and recognize obstructions on the highway depends not upon intensity of light but upon contrast. For instance, take the most powerful motor vehicle headlights made and point them along a straight highway on a dark night. If there is a man standing in the centre of the road half a mile away, the chance of seeing him is very small if his clothes are the same colour as the background. If, now, the headlights are turned out and an oil lantern is held behind the man, you will easily be able to recognize the shape of the man against the illuminated background of the pavement—because of the silhouette effect.

Would it not, therefore, be far better to do away with powerful headlights which are ineffective for their purpose, besides adding a further hazard—glare—and illuminate some of our more travelled highways with well-designed, although comparatively low intensity, scientific highway-lighting?

TABLE VI

Effect of Darkness on Fatal Accidents on the King's Highways Only

	Traffic on Highways			Fatal Accidents	
	Daylight	Dark		Daylight	Dark
Average for 1930	81%	19%		69%	31%
If traffic had been	50%	50%	accidents would have been	35%	65%
Average for 1931	83%	17%		61%	39%
If traffic had been	50%	50%	accidents would have been	24%	76%
Average for 1932	80%	20%		71%	29%
If traffic had been	50%	50%	accidents would have been	39%	62%

Taking the average for three years, if traffic had been equally dense day and night, there would have been twice as many fatalities during the night, which means the hazard is twice as great.

Furthermore, headlights, to be at all effective in showing up the road and objects upon it, require very careful focussing of bulbs and plumbing of lamps—operations that involve a human factor and that are easily nullified by vehicle vibration and road shocks. Errors in adjustment producing glare—the cause of probably most night highway accidents—are aggravated in proportion to the candlepower of the bulbs. As unsatisfactory as the present standard 21 cp. bulbs may be, 32 cp. bulbs would only create a worse hazard. Why not, therefore, place dependence upon a system of lighting that can be properly adjusted in the first place and that, once adjusted, remains permanent, giving adequate light on the road without recourse to the vagaries of inefficient motor car headlights?

The Economic Loss

The direct total property loss in motor vehicle accidents in Ontario alone in which there was personal injury or property damage in excess of $50, amounted, during 1932, to $994,510, or $1.89 every minute of the year. How small a part of the economic loss this really represents may be seen from the fact that in all accidents involving pedestrians there was a property damage of only $9,528, though in these accidents 230 persons were killed, and 2,737 injured, many of whom were permanently disabled and have become, instead of economic assets, economic liabilities for the balance of their lives.

Once again the greater seriousness of rural accidents is indicated by the damage which resulted. The average loss per reported accident in Ontario on the urban streets was $66.61, while on the rural roads the average per reported accident was $173.18 or more than two and a half times as great. The damage loss in most cases reflected the comparative seriousness of various types of accidents as disclosed by a study of the number of persons killed or injured. Thus, railroad crossing accidents, recognized as the most serious, proportionally, of all types of accident and of which almost one third resulted in fatalities, cost, on an average, $291.16 per accident in property damage and far exceeded any other type in average costs. Collisions with street cars, and collisions between motor vehicles, also proved costly; the latter type of accident resulted in over 58 per cent. of the total damage reported.

But, as has been said, the cost of replacing damaged vehicles and other property is but a small part of the cost of accidents. A conservative estimate of the total waste places the figure for Ontario at approximately fifteen million dollars. One cannot, however, measure the loss of a mother by the amount of wages required to replace her in the household, nor can one measure the loss of a child by the loss of his future earning power. It is not possible to measure the number of potential car buyers who do not buy cars because of high insurance rates, or because they are afraid to let their wives or children drive because of present traffic hazards, nor is it possible to compute the loss to the automotive industry resulting from these effects.

Whatever the dollars-and-cents cost of road accidents may be, the resulting

loss of life, health, money, and time, are imposing an unnecessary burden upon the shoulders of every man, woman, and child in this Dominion. It is an indirect tax which is paid by every member of the community, whether he realizes the fact or not. Reduced earning power means reduced purchasing and spending power, and affects the income of all classes. *If by improving the lighting on city streets, and by illuminating some of our more travelled highways, we can greatly reduce this large economic loss, we shall at least be making a truly dividend-paying investment.*

MANY ECONOMIC ADVANTAGES IN LIGHTING

Really adequate lighting on our main highways would most certainly prevent many night time catastrophes. In addition, it would bring many other outstanding advantages with it.

1. To the nation, it would mean greatly improved transportation facilities at little extra cost. In addition, it would mean a great saving in life and a large saving in what is now a direct economic loss amounting to millions of dollars annually.

2. To the farmer, where there are no existing distribution lines, it would mean electrification with all its increased efficiency on the farm.

3. To the motorist it would mean fewer accidents and less nervous tension.

4. To the central station, it would mean overhead on rural lines.

5. To the provinces, it would mean fewer crimes and less policing, and greatly increased tourist traffic.

6. To the electrical industry, it would bring a large potential rural market.

LOW LIGHTING MAINTENANCE COSTS

The cost of highway lighting is very much smaller than would be expected. Comparatively, it is very small, for the average cost of road construction per mile is $50,000, whereas the average rural cost of lighting per year, per mile, is only $1,000 to $1,500,* or 2 to 3 per cent. of the road construction cost. In fact it could be readily argued that the lighting of many of our arterial provincial highways would easily pay for itself.

—*Published with permission.*

* Note: these figures are for incandescent lamps. Operation of gaseous discharge lamps, such as are being used in Europe, are said to cost very much less.

The Radio Equipped Car Locates Power Line Faults

By F. B. Shand, Distribution Section, Electrical Engineering Dept., H.E.P.C. of Ont.

THE "Radio Car" of the radio branch of the Department of Marine, equipped with the directional loop, exploring coil, etc., has rendered invaluable service to the radio receiving public in locating the source of many inductive disturbances.

During the past summer, in the Distribution Section of the Electrical Engineering Department, use has been made of a standard auto radio set, installed in the usual manner and without special attachments; it has been found that this equipment provides a simple and expeditious method of locating faulty equipment and other conditions of improper construction or operation.

The detection and correction of such faults not only removes the source of radio interference but in many cases forestalls more serious breakdown of apparatus and consequent interruption to the power service.

In one case a consumer had been complaining for more than a year that the rural power line was causing radio interference. The rural superintendent and lineman had made several trips to this location examining fuse switches, lightning arresters, line connections, etc., but in each case, without success. While in the district with the auto radio the superintendent and lineman were driven along the rural line at this location and were surprised to find the reception very good. The consumer was then asked to operate his receiving set but results showed no improvement. When, therefore, he was shown that the auto radio gave no indication of interference, even in close proximity to the power line and equipment which was suspected of being faulty, he was satisfied that the trouble was in his own receiving set. This relieved the superintendent of any further expense in investigating the complaint.

Another case concerned a condition where no complaint had been made. At various times while driving along the road, and parallel to a rural power line, a definite disturbance was noticed. In one instance the trouble was found to be a loose connection on the secondary bus. In another, loose contacts of the transformer fuse switches were responsible. These faults were of such a nature that ultimately would have caused unsatisfactory operation and expense to locate and correct.

Another interesting condition was encountered while driving along a 4,000 volt feeder line. The neutral conductor of this line was grounded at every fifth pole, and the connection at the top of the pole had been made simply by turning the end of the ground wire around the neutral conductor three or four times. As the car approached each of these grounded

points a definite interference was heard on the receiving set. Undoubtedly this was due to an unbalanced load on the line causing current to flow through the loose connections to ground. In this case it was recommended that the phase loading be checked for balance.

In general, radio reception is affected by disturbances from power line faults for a distance of 45 or 50 feet. The conductor on which this fault occurs, or any other conductors in the immediate vicinity, however, may transmit this disturbance in a diminishing degree for a considerable distance. As the radio equipped car approaches a power line fault, therefore, the intensity of the interference increases and, of course, decreases as the fault is passed, provided the car is running parallel to the transmitting line. The location of the fault is then roughly determined as being near the car when the intensity of interference reaches a maximum. With this information a lineman soon locates the trouble.

The standard auto radio has proven conclusively to be of great advantage in the investigation of interference complaints, the detection of certain unsatisfactory or hazardous operating conditions, and the prevention of some service interruptions. With further experience and study many other uses will no doubt be found, rendering service of greater value to the consumer and assisting in retain ing the good will of the public.

Thomas Edward Lipsey, Elora

The death occurred at his home on Moir Street, Elora, on Wednesday, December 6, 1933, after a short illness, of Thomas Edward Lipsey, in his 79th year. Word of his passing was received with general regret as Mr. Lipsey had for half a century occupied a prominent part in the industrial, civic and church life of that community and was well known throughout the whole district.

The late Mr. Lipsey was born at Pickering, Ontario, and was a miller by trade. Before going to Elora some 49 years ago, he operated a flour mill at Cataract and later Pipe's Mills, at

Guelph. For a short period after arriving in Elora he was with James Hortop in the flour mill there. He then entered into partnership with Richard Stickney under the firm name of Lipsey and Stickney, operating an oatmeal mill. This partnership was later dissolved, Mr. Lipsey going into the insurance business. He always took a deep interest in municipal affairs. He was for eight years Reeve of Elora and served on the Elora Hydro-Electric Commission since its inception nineteen years ago, being chairman of that body for a number of years. He was a popular member of the County Council.

The late Mr. Lipsey was married fifty-three years ago and is survived by his widow, one daughter and two grandchildren.

The funeral, which was very largely attended, took place at Elora on Friday, December 8, 1933.

Electricity Not Dangerous

Within the city limits of Chicago live 3,376,438 people. In this number of people there were eight fatal electrical accidents in 1932, according to the recently published annual report of the Chicago Department of Gas and Electricity. Of the eight at most four can be said to be directly attributable to accidental contacts with wiring and equipment used in home or industry. But assuming all eight fatalities as due to faulty materials and devices, the ratio of deaths to population is 0.0000023, or about two in a million. Statistics thus show that electricity in actual use is infinitely less dangerous to life than many other common hazards that are given far less thought in safety standardization. The record:

1. Electrical equipment involved—Extension cord.

Injury, shock. Voltage, 115 a.c.
Occupation, watchman. Age, 40.
Location of accident, boiler room of a laundry.
Contacts—Hands on wet brass shell of socket attached to an extension cord, feet on wet cement floor.
Defects—Type of socket not approved for location or use.
Occupation at time of accident—Cleaning boiler.

2. Electrical equipment involved—Extension cord.

Injury, shock. Voltage, 115 a.c.
Occupation, bathhouse attendant. Age, 48.
Location of accident—Passageway in basement of public bath house.
Contacts—Some part of body (naked and wet at the time) with the cord while standing on damp earth floor.
Defects—Insulation of N.E. Code Type C lamp cord cracked in many places, also a splice insulated with medical tape.
Occupation at time of accident—Walking through passageway.

3. Electrical equipment involved—Portable electrical drill.

Injury, shock. Voltage, 3 phase, 220, maximum to ground approximately 190.
Occupation, laborer. Age, 57.
Location of accident—Coal storage yard.

Contacts—Frame of portable drill to earth.

Defects—Insulation failure; cause unknown.

Occupation at time of accident—Drilling holes in conveyor.

4. Electrical equipment involved—B battery eliminator for radio receiver.

Injury, shock. Voltage, depending on terminal used, maximum 200 d.c.

Occupation, structural iron worker, unemployed. Age, 47.

Location of accident—Bedroom in rooming house.

Contacts—Bottom sections of safety razors, one on each breast held in by a belt and attached by flexible wires to the d.c. terminals of a B eliminator.

Occupation at time of accident—Experimenting with electrical treatment.

5. Electrical equipment involved—Radio receiving set and microphone.

Injury, shock. Voltage, d.c., 245.

Occupation, school boy. Age, 18.

Location of accident—Living room of his home.

Contacts—Metal case of microphone in one hand with the other hand on metal chassis of the receiver.

Defects—Designed and connected so that plate potential of detector tube exists between case of microphone and ground terminal of the receiving set.

Occupation at time of accident—Connecting the microphone to receiving set in order to reproduce his voice in the speaker.

6. Electrical equipment involved—Third and running rails of elevated railroad.

Injury, shock. Voltage, d.c., 600.

Occupation, switchman. Age, 28.

Location of accident—Terminal yards of elevated railroad system.

Contacts—Body across third and running rails.

Defects—None; heavy rainstorm was a contributing cause.

Occupation at time of accident—Switching cars; slipped on wet tie.

7. Electrical equipment involved—Light pole of street lighting system.

Injury, shock and skull fracture. Voltage a.c., 2,300.

Occupation, school boy. Age, 18.

Location of the accident—Metal light pole on city street.

Contacts—One hand on lamp housing, the other hand and both feet on the pole.

Defects—None; a trespasser trying to remove the lamp.

8. Electrical equipment involved—Wires of street lighting system on poles and running through trees.

Injury, shock and skull fracture. Voltage, 2,800 a.c.

Occupation, school boy. Age, 18.

Location of the accident—Tree on city street.

Contacts—One hand on wire, the other hand and feet on cottonwood tree.

Defects—None.

Occupation at time of accident—Playing.

—Electrical World.

Association of Municipal Electrical Utilities

Convention Programme

The Winter Convention of the Association of Municipal Electrical Utilities will be held jointly with the Ontario Municipal Electric Association at the King Edward Hotel on January 31st and February 1st, 1934. The programme of this Convention, as so far arranged, shows that the proceedings will be as in the following. Everything will take place at the King Edward Hotel, excepting the Convention Luncheon on January 31st, 1934. As both Associations are to be the guests of the Electric Club of Toronto at their luncheon on that day, the Associations will proceed to the Royal York Hotel for that part of the programme only.

WEDNESDAY—January 31st, 1934.

MORNING—Registration.

10.00 o'clock (in Alexandra Room).
O.M.E.A. Annual Meeting.
10.30 o'clock (in Yellow Room).
A.M.E.U. Convention Session.
Receiving reports of Committees.

AFTERNOON—

12.30 o'clock (in Concert Hall, Royal York Hotel).
Convention Luncheon.
Address by the Honourable J. R. Cooke, Chairman, Hydro-Electric Power Commission of Ontario.
2.30 o'clock (in Alexandra Room).
O.M.E.A. Annual Meeting.
2.30 o'clock (in Crystal Ball Room).
A.M.E.U. Convention Session.
Election of Officers for 1934. Ballots will be distributed to delegates when registering and up to the opening of this session. These should be marked and deposited in the Ballot box, which will be closed immediately after this session opens. The results of the elections will be announced before adjournment for dinner.
Paper — "Better Light — Better Sight", by George G. Cousins, Testing Engineer in Charge, Illumination Laboratory, H.E.P.C. of Ontario, followed by discussion.
Paper—"Mechanical Billing Methods", by H. L. Summerlee, Burroughs Adding Machine of Canada, Limited, Toronto, followed by discussion.

EVENING—

6.30 o'clock (in Crystal Ball Room).
Convention Dinner (O.M.E.A. and A.M.E.U.)
Entertainment.
Address.

THURSDAY—February 1st, 1934.

MORNING—

9.30 o'clock (in Alexandra Room).
A.M.E.U. Convention Session.
Paper—"Domestic Load Possibilities", by H. C. Powell, Statistician, Toronto Hydro-Electric System, followed by discussion.
Paper—"Future Applications of Electrical Energy", by W. P. Dobson, Chief Testing Engineer, H.E.P.C. of Ontario, followed by discussion.

AFTERNOON—

12.30 o'clock (in Crystal Ball Room).

Convention Luncheon (O.M.E.A. and A.M.E.U.).

Address.

2.30 o'clock (in Alexandra Room).

A.M.E.U. Convention Session.

Discussion—"Experiences on Water Heater Campaign", by delegates from various municipal utilities.

Paper—"Copper", by O. W. Titus, Consulting Engineer, Canada Wire and Cable Company, Limited, Toronto, followed by discussion.

* * * *

Election Ballot

The ballot for officers of the Association of Municipal Electrical Utilities for the year 1934 will show the following names:

President—W. R. Catton, Brantford, (Acclamation).

Vice-President—O. M. Perry, Windsor, R. J. Smith, Perth.

Secretary—S. R. A. Clement, H.E.P.C. of Ont., Toronto, (Acclamation).

Treasurer—H. T. Macdonald, H.E.P.C. of Ont., Toronto.

D. J. McAuley, H.E.P.C. of Ont., Toronto.

Directors—(*from the membership at large*).

E. V. Buchanan, London.
G. E. Chase, Bowmanville.
D. B. McColl, Walkerville.
V. S. McIntyre, Kitchener.
R. S. Reynolds, Chatham.
O. H. Scott, Belleville.

District Directors

Niagara District:—

A. B. Manson, Stratford.
P. B. Yates, St. Catharines.

Central District:—

R. O. Quick, Brighton.
C. A. Walters, Napanee.

Georgian Bay District:—

C. E. Brown, Meaford.
R. S. King, Midland.
J. R. McLinden, Owen Sound.

Eastern District:—

J. D. Grant, Smiths Falls.
M. W. Rogers, Carleton Place.

Northern District:—

C. J. Moors, Fort William, (Acclamation).

Ballots will be distributed during the morning of the first day of the Convention, January 31, 1934. Immediately after the opening of the afternoon session on that day, the ballot box will be closed. The results of the elections will be announced before the closing of that session.

Index to Volume XX